FEM 1209:480307

FLOOD INSURANCE STUDY

ORIGINAL

CITY OF PASADENA, TEXAS
HARRIS COUNTY

JUNE 3, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 480307

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Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

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FLOOD INSURANCE STUDY
CITY OF PASADENA, TEXAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Pasadena, Harris County, Texas, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in their efforts to promote sound flood plain management. Minimum flood plain management requirements for participation in the National Flood Insurance Program are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This study represents a revision of the original analyses prepared for the Federal Emergency Management Agency (FEMA). The updated hydrologic and hydraulic analyses for this study were prepared by the U. S. Army Corps of Engineers (COE) for FEMA, under Inter-Agency Agreement No. H-07-76, Project Order No. 14 and Amendment 3 thereto, and Inter-Agency Agreement No. H-10-77, Project Order No. 1 and Amendments thereto. Portions of the hydrologic and hydraulic analyses for this study were revised by the Harris County Flood Control District (HCFCD) to take into account rapid development and improvements which were made to the watersheds since the completion of the original study. The coastal analyses were performed by Tetra Tech, Inc., under Contract No. H-4788 and amendments thereto. The COE and Tetra Tech, Inc., completed their work in June 1982. The HCFCD completed their work in September 1983.

1.3 Coordination

The study for the City of Pasadena was conducted as a part of the Harris County Flood Insurance Study. Initial Consultation and Coordination

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Officer's (CCO) meetings were held at different locations in Harris County from May 10 through May 13, 1976. Appropriate city, county, and state officials were invited to attend. The meetings were conducted by representatives of FEMA with participation by representatives of the COE (the study contractor). The purposes of the meetings were to determine the streams to be studied in detail, discuss the National Flood Insurance Program, and obtain flood information currently available concerning the community. The U. S. Geological Survey (USGS) provided topographic and hydrologic data for this study.

In December 1982, meetings were held between the HCFCD and FEMA to discuss the COE analyses. They decided that certain watersheds would be restudied by the HCFCD. These restudies would then be released with the remaining COE analyses at a later date.

On November 13, 1984, the results of the study were reviewed at a final CCO meeting attended by representatives of FEMA and the city.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area, including several industrial districts, of the City of Pasadena, Harris County, Texas. The Pasadena Industrial District, an area under the jurisdiction of Harris County, is not included in this study. The area of study is shown on the Vicinity Map (Figure 1).

The following riverine flooding sources were studied by detailed methods: Taylors Bayou (A104-00-00), Tributary 3.93 to Taylors Bayou (A104-07-00), Armand Bayou (B100-00-00), Horsepen Bayou (B104-00- 00), Big Island Slough (B106-00-00), Spring Gully (B109-00-00), Tributary 9.40 to Armand Bayou (B111-00-00), Willow Springs Bayou (B112-00-00), Tributary 10.46 to Armand Bayou (B113-00-00), Tributary 12.18 to Armand Bayou (B115-00-00), Buffalo Bayou (W100-00-00), Glenmore Ditch (G108- 00-00), Tributary 6.77 to Buffalo Bayou, Tributary 8.17 to Buffalo Bayou, Vince Bayou (I100-00-00), and Little Vince Bayou (I101-00-00). Tidal flooding was studied by detailed methods along Galveston Bay, Buffalo Bayou, Clear Creek (Clear Lake) (A100-00-00), Forrest Lake and Armand Bayou, and Taylor Lake and Taylors Bayou. Combined riverine and surge flooding were studied for all areas where riverine and surge flooding interface. Analyses of these studies determined that flooding affecting the City of Pasadena from rainfall runoff is insignificant along Buffalo Bayou, Tributary 8.17 to Buffalo Bayou, Tributary 3.36 to Buffalo Bayou, Clear Creek (Clear Lake) (A100-00-00), Forrest Lake, Taylor Lake and Taylors

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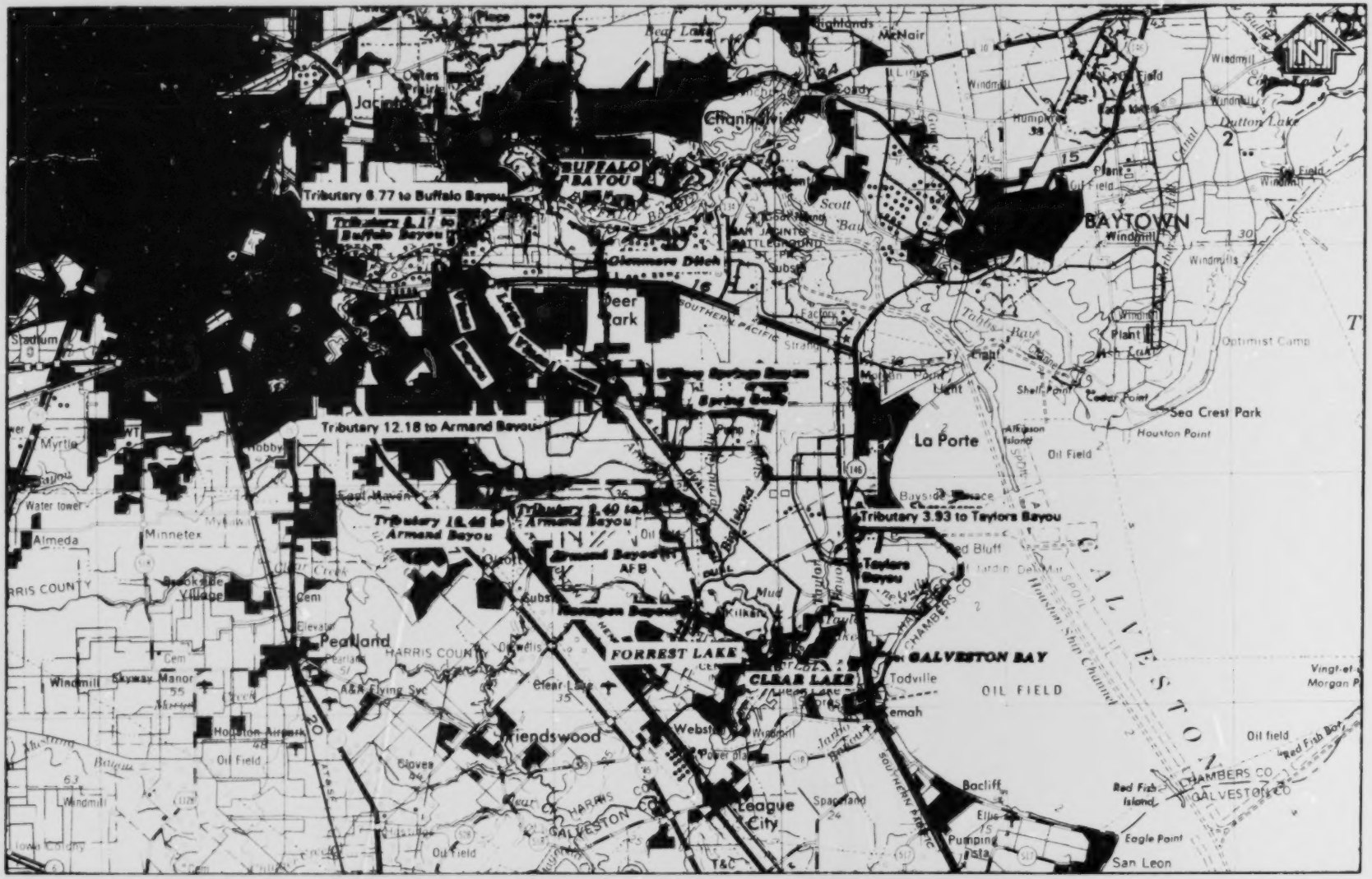

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

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Bayou, and Tributary 3.93 to Taylors Bayou. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction through September 1988.

Portions of Armand Bayou, Tributary 10.46 to Armand Bayou, and Little Vince Bayou were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the City of Pasadena.

2.2 Community Description

The City of Pasadena is located in the southern portion of Harris County in southeastern Texas. It is bordered by the Cities of Houston and South Houston to the west, the Cities of Seabrook and Shoreacres to the southeast, the Cities of Taylor Lake Village and El Lago to the south, the Cities of LaPorte and Deer Park to the northeast, and the unincorporated areas of Harris County to the west and north.

Pasadena was founded in 1895 and named after the city of the same name in California. The present Home Rule Charter was adopted in December 1964. The city is governed by a mayor and six councilmen, and maintains its own police and fire departments (Reference 1).

The economy of Pasadena and the surrounding area strongly reflects the petrochemical and port activities associated with the navigation facilities along the Houston Ship Channel, which is immediately north of the city. The 1980 population of the city was 112,960, a 26-percent increase from 1979 (References 2 and 3).

The topography of the area is relatively flat. Natural vegetation has largely been replaced by a wide variety of lawn grasses, shrubs, and trees typically used for landscaping. The climate of Pasadena is characterized by warm summers and mild winters. The normal annual temperature was 68.9 degrees Fahrenheit (°F) from 1941 through 1970 (normal temperature is defined as the 30-year average of the mean daily temperatures). Over the same period, the highest monthly average temperature was 83.4°F for August, and the lowest was 52.1°F for January. The average annual rainfall was 48.19 inches (Reference 4).

The most recent phase of geologic history for the study area began with the onset of the Late Wisconsin glacial stage, when sea level dropped during the last period of glaciation. Rivers along the Texas coast could no longer shift from their courses, thus building deltas along a new

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shoreline on the continental shelf. Deep, broad valleys were cut across the earlier fluvial and delta plains. As the last glacial period diminished approximately 18,000 years ago, sea level began its most recent rise. Large point-bar sand bodies and extensive overbank mud sheets were deposited as rivers meandered within the filling valleys.

In the last 4,500 years, sea level has been relatively constant, probably changing in elevation only 10 to 15 feet. In modern times, the study area has evolved to its present conditions by erosion, deposition, compaction, and subsidence. These processes are still important and operating today (References 5, 6, and 7).

Buffalo Bayou flows east, parallel to, but outside of, the northern corporate limits of Pasadena. Glenmore Ditch, Tributary 6.77 to Buffalo Bayou, and Tributary 8.17 to Buffalo Bayou flow north into Buffalo Bayou and drain relatively small areas of the northern portion of the city. Vince Bayou and Little Vince Bayou flow northwest into Buffalo Bayou and drain the western and central portions of the city. Taylors Bayou, Tributary 3.93 to Taylors Bayou, Armand Bayou, Horsepen Bayou, Big Island Slough, Spring Gully, Tributary 9.40 to Armand Bayou, Willow Springs Bayou, Tributary 10.46 to Armand Bayou, and Tributary 12.18 to Armand Bayou flow south into Clear Creek (Clear Lake), draining the central and southeastern portions of Pasadena.

The metropolitan area around the City of Houston is one of the fastest growing regions in the country. As a result, the incorporated communities in this area are expanding at a rapid rate through annexation of land from the surrounding counties. This makes it difficult to maintain current political boundaries in the Flood Insurance Studies for these communities. If annexation of additional areas has taken place, flooding information for these portions of land can be found in the Flood Insurance Study for the county from which they were annexed until the Pasadena study is revised.

2.3 Principal Flood Problems

The study area is subject to intense local thunderstorms of short duration, general storms extending over periods of several days, and torrential rainfall associated with hurricanes and other tropical disturbances. Flooding in the city results from tidal surges along Galveston Bay caused by hurricanes and tropical storms, and from streamflow. A high-water mark of 16.4 feet was recorded near the Galveston Bay shoreline in Pasadena following Hurricane Carla in September 1961 (Reference 8).

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2.4 Flood Protection Measures

A federal flood control project for Vince Bayou and Little Vince Bayou has been authorized and will provide for the rectification of Vince Bayou from its confluence to a point approximately 7.2 miles upstream and of Little Vince Bayou from its confluence to a point approximately 4.2 miles upstream. The improvements are designed to provide protection from floods greater than the 100-year flood. The work on Vince Bayou has been completed; however, due to land subsidence and other changes in the area, construction of the Little Vince Bayou improvements was not started until early 1984. The completion date is still unknown.

No other structural flood control measures other than normal drainage facilities are known to exist in the study area.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships and peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

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A set of predictive equations was developed to compute peak flood flows for the streams affecting the study area. Flood flows used in the riverine analyses were computed using regression equations developed by the Galveston District of the COE. These equations relate 10-, 50-, 100-, and 500-year frequency flood flows to pertinent basin characteristics. To develop the equations, the COE estimated flood-flow frequency relationships for 19 gaged basins in the Houston metropolitan area using the annual maximum flood flows at each gage. Multiple linear regression techniques were used to relate the selected frequency flood flows at each gage to the characteristics of its watershed. The results of the regression analysis were four arithmetic expressions equating the required peak flows to functions of the basin drainage area and effective channel conveyance at the point of computation.

This analysis was conducted solely to develop flows for studies in Harris County. The resulting equations have not been published for public or private use as they are not suitable for general application; however, the procedure used is similar to that described in the USGS Water Resources Investigations Publication No. 3-73 (Reference 9).

The predictive equations are sensitive to changes in stream conveyance, however, a technique was developed to moderate this sensitivity. The technique involves the use of the HEC-2 computer program to compute conveyance data along the stream and incorporate these data into a smooth curve (Reference 10). Conveyance values were then taken from the curve, thus avoiding unwarranted values for peak flows which might result from erratic conveyance values if taken at arbitrary points along the stream.

The hydraulic analyses for this study were developed by the COE and the HCFCD. From 1977 to 1979, the COE developed various hydrologic methodologies for all the watersheds within the county. In 1983, the HCFCD developed revised methodologies to reflect the rapid development that had occurred in the county since 1979. Only the areas that experienced significant improvements or changes were studied. This study included the following streams: Taylors Bayou, Tributary 3.93 to Taylors Bayou, Armand Bayou, Horsepen Bayou, Big Island Slough, Spring Gully, Tributary 9.40 to Armand Bayou, Willow Springs Bayou, Tributary 10.46 to Armand Bayou, Tributary 12.18 to Armand Bayou, Glenmore Ditch, Vince Bayou, and Little Vince Bayou. The hydrologic methodologies are summarized in the following pages.

HCFCD HYDROLOGY

Two major hydrologic methodologies were developed by the HCFCD for the streams studied by detailed methods. The first methodology was developed for drainage areas of greater than 10 square miles, while the second was

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developed for drainage areas of less than 10 square miles. A detailed description of this hydrologic analyses is available to the public through the HCFCD (Reference 11). A summary of these methodologies is presented below.

Drainage Areas Greater than 10 Square Miles

The HEC-1 computer program was used for drainage areas greater than 10 square miles (Reference 12). The purpose of the HEC-1 program is to determine peak discharges at various locations within a watershed. The most useful feature of the program is its capacity to model flood runoff from a single storm event for a complex river basin. To model a basin, topologic features must be described, and the precipitation runoff parameters must be defined and entered into the computer program. The topologic features include drainage basin boundaries, stream channels, and relationships between drainage areas and stream channels. Average rainfall values are used for each sub-basin. Runoff is computed from average basin parameters and, therefore, requires a unit hydrograph and a loss rate criteria. The program considers routing to be governed by storage and can be computed by one of several hydrologic methods, each with its own set of parameters.

The process of the HEC-1 program includes inputting and distributing the precipitation, determining the sub-basin outflow hydrographs from unit hydrograph methods, computing rainfall and excess values, and routing hydrographs by hydrologic methods. This hydrologic methodology was used to develop the discharges for most of the county. The Clark's unit hydrograph parameters of time of concentration (T_C) and attenuation constant (R) were optimized from a regression analysis evaluating the storm events obtained at various gages. Percent of urbanization was taken into account by separating the above data into three categories: (1) undeveloped, (2) partially developed, and (3) developed conditions.

The above regression analysis showed the equation for T_C to be a function of overbank slope, length to centroid of area, urbanization, and weighted channel slope; while, the equation for T_C+R was found to be a function of the length of the watershed to the divide, the weighted channel slope, urbanization, and channel conveyance. Ponding, caused by extensive rice farming in the southern and western portions of the county, was taken into account by developing a relationship between percent ponding and R. This relationship was obtained from the U. S. Soil Conservation Service (SCS) publication Technical Release 55, Urban Hydrology for Small Watersheds (Reference 13). The SCS methodology which incorporates the use of runoff curve numbers and soil type was used to estimate loss rates (Reference 14).

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Drainage Areas Less Than 10 Square Miles

Drainage area-discharge curves were developed for each watershed with a drainage area less than 10 square miles. These curves are based on an average watershed channel slope and an average watershed overbank slope.

Unit hydrograph coefficients of T_c and R were calculated using the equations presented in the previous section. To determine the length to watershed divide and the length to centroid of axis, a regression analysis was performed between these values and the drainage area, yielding a high correlation.

A HEC-1 model utilizing the kinematic wave option, was constructed for different drainage areas using design storm rainfalls and loss rates. The computed flows were plotted on full-log graph paper, which resulted in the final drainage area-discharge curves for the watershed.

A summary of drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges".

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
TAYLORS BAYOU (A104-00-00) At confluence with Clear Creek (Clear Lake) (A100-00-00)	16.18	2,480	3,520	4,070	5,300
TRIBUTARY 3.93 TO TAYLORS BAYOU (A104-07-00) At confluence with Taylors Bayou (A104-00-00)	2.23	575	805	910	1,160
ARMAND BAYOU (B100-00-00) At confluence with Clear Creek (Clear Lake) (A100-00-00)	61.74	15,780	20,690	23,300	28,900

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TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
ARMAND BAYOU (B100-00-00) (continued)					
At confluence of Horsepen Bayou (B104-00-00)	37.86	9,760	12,650	14,340	17,100
At confluence of Big Island Slough (B106-00-00)	27.89	7,190	9,460	10,370	12,600
At confluence of Spring Gully (B109-00-00)	21.50	6,070	7,950	8,780	10,500
At confluence of Willow Springs Bayou (B112-00-00)	10.87	3,220	4,360	4,940	6,150
HORSEPEN BAYOU (B104-00-00)					
At confluence with Armand Bayou (B100-00-00)	19.28	5,700	7,510	8,390	10,200
BIG ISLAND SLOUGH (B106-00-00)					
At confluence with Armand Bayou (B100-00-00)	8.75	3,280	4,530	4,920	6,100
SPRING GULLY (B109-00-00)					
At confluence with Armand Bayou (B100-00-00)	3.28	1,350	1,850	2,070	2,600
TRIBUTARY 9.40 TO ARMAND BAYOU (B111-00-00)					
At confluence with Armand Bayou (B100-00-00)	2.52	920	1,270	1,430	1,800
WILLOW SPRINGS BAYOU (B112-00-00)					
At confluence with Armand Bayou (B100-00-00)	7.14	2,890	3,810	3,950	4,650

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TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
TRIBUTARY 10.46 TO ARMAND BAYOU (B113-00-00)					
At confluence with Armand Bayou (B100-00-00)	3.17	895	1,250	1,410	1,780
TRIBUTARY 12.18 TO ARMAND BAYOU (B115-00-00)					
At confluence with Armand Bayou (B100-00-00)	3.43	1,750	2,310	2,570	3,160
BUFFALO BAYOU (W100-00-00)					
At confluence with Glenmore Ditch (G108-00-00)	*	66,000	124,000	159,000	263,000
GLENMORE DITCH (G108-00-00)					
At confluence with Buffalo Bayou (W100-00-00)	3.27	1,370	2,240	2,660	3,760
At river mile 1.09	2.79	1,180	1,910	2,280	3,230
At river mile 2.33	1.84	840	1,380	1,620	2,300
TRIBUTARY 6.77 TO BUFFALO BAYOU					
At confluence with Buffalo Bayou (W100-00-00)	1.34	250	430	560	1,020
TRIBUTARY 8.17 TO BUFFALO BAYOU					
At confluence with Buffalo Bayou (W100-00-00)	0.50	75	140	200	510

*Data not available

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TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
VINCE BAYOU (I100-00-00)					
At stream mile 0.72	14.79	6,950	8,650	10,200	12,400
At stream mile 1.58	9.16	6,490	7,680	9,590	11,700
At stream mile 1.77	8.53	6,020	7,130	8,900	10,800
At stream mile 2.23	7.33	5,760	6,130	8,400	10,200
At stream mile 3.15	6.20	4,610	5,610	6,760	8,220
At stream mile 3.74	5.00	3,530	4,160	5,170	6,280
At stream mile 4.38	4.49	3,120	3,480	4,520	5,490
At stream mile 4.82	3.68	2,610	2,960	3,850	4,680
At stream mile 4.83	2.93	2,040	2,740	3,030	3,680
At stream mile 5.92	1.59	1,160	1,530	1,680	2,040
LITTLE VINCE BAYOU (I101-00-00)					
At confluence with Vince Bayou (I100-00-00)	4.78	2,315	2,760	2,960	3,500
At stream mile 2.38	3.38	1,680	2,020	2,170	2,560
At stream mile 2.42	2.73	1,350	1,630	1,750	2,070
At stream mile 2.87	1.98	1,000	1,210	1,270	1,500

The determination of coastal inundation caused by the passage of a hurricane was approached using the joint probability method (Reference 15). The storm population was described by probability distributions of five parameters that influence surge heights. These five parameters include central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle.

These parameters, or storm characteristics, were described statistically as based on an analysis of observed storms in the vicinity of Galveston Bay. Primary sources of data were the National Weather Service and the National Hurricane Research Project (References 16, 17, 18, 19, and 20).

To establish the 10-, 50-, 100-, and 500-year flood elevations in Galveston Bay, the FEMA standard coastal surge model was used to simulate the coastal surge generated by any chosen storm (that is, any combination of the five storm parameters previously defined). Performing such simulations for a large number of storms, each of known total probability, permitted the establishment of the frequency distribution of surge height as a function of coastal location. It should be noted that

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these distributions incorporate the large scale surge behavior, but do not include an analysis of the added effects associated with much finer scale wave phenomena such as wave height, setup, or runup. The astronomic tide for the region was then statistically combined with the computed storm surge to yield recurrence intervals of total water level. The entire procedure is detailed in the Coastal Flooding Handbook (Reference 21).

A one-dimensional unsteady branch flow model was used to determine surge elevations along the stream and tidal estuaries in Harris County (Reference 22). The one-dimensional surge model is the same as described in the Coastal Flooding Handbook, except in its capability of handling hydraulic parameters which vary with elevations (Reference 21). With that addition, the model is able to incorporate the physical aspects of natural stream channels and their flood plains. The streams and tidal estuaries considered for the Pasadena study were Galveston Bay, Clear Creek (Clear Lake), Forrest Lake, Buffalo Bayou, Armand Bayou, and Taylor Lake and Taylors Bayou.

Both the two-dimensional surge model and the one-dimensional model were verified with Hurricane Carla data (Reference 8). Computations for the surge levels along the streams and estuaries were performed without including the effect of any rainfall runoff.

After an analysis of riverine flooding and an analysis of tidal flooding was completed along Taylors Bayou, Tributary 3.93 to Taylors Bayou, Armand Bayou, Big Island Slough, and Spring Gully, the events were combined using combined probabilities. For specific elevations, the recurrence intervals of separate events were added together to find the recurrence interval for the combined event. The following equation was used:

$$T_R \text{ combined} = 1/[1/T_R \text{ riverine} + 1/T_R \text{ surge}]$$

where T_r riverine is the recurrence interval of the riverine event at a specific elevation, T_R surge is the recurrence interval of the tidal event at the same elevation, and T_R combined is the recurrence interval of the combined riverine and tidal event at the same elevation.

The inclusion of wave heights, which is the distance from the trough to the crest of the wave, increases the water-surface elevations. The height of a wave is dependent upon wind speed and its duration, depth of water, and length of fetch. The wave crest elevation is the sum of the stillwater elevation and the portion of the wave height above the stillwater elevation.

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Wave heights and corresponding wave crest elevations were determined using the National Academy of Sciences (NAS) methodology (Reference 23). The stillwater elevacions, combined surge and riverine elevations, and maximum wave crest elevations of selected recurrence intervals are shown in Table 2, "Summary of Stillwater Elevations."

TABLE 2 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR[1]	50-YEAR[1]	100-YEAR	500-YEAR[1]
GALVESTON BAY				
At Red Bluff	5.3	10.0	11.8/18[2]	15.4
CLEAR CREEK (CLEAR LAKE)				
At the confluence with Forrest Lake	4.8	9.6	11.4/15[2]	14.7
FORREST LAKE				
At the confluence with Clear Lake	4.8	9.6	11.4/15[2]	14.7
Across from Honey Oats Drive	4.8	9.7	11.4[1]	14.8
BUFFALO BAYOU				
At the confluence of Tributary B of Buffalo Bayou	5.2	9.9	11.5[1]	14.9
At the confluence of Cotton Patch Bayou	5.3	10.0	11.6[1]	15.0
At the confluence of Vince Bayou	5.3	10.0	11.6[1]	15.0
ARMAND BAYOU				
At Bay Area Boulevard	4.8	9.7	11.5[1]	14.8
TAYLOR LAKE AND TAYLORS BAYOU				
At Red Bluff Road	4.8	9.7	11.4[1]	14.8
At Port Road	4.8	9.7	11.4[1]	14.8

[1]Stillwater Elevation
[2]Stillwater Elevation/Maximum Wave Crest Elevation

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3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Topographic data on backwater-producing structures, channel cross sections, and valley cross sections used for backwater computations were obtained by field survey and supplemented with information from USGS topographic maps and aerial photographs (References 24 and 25). All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 10). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. Starting water-surface elevations were determined using the slope/area method.

Recorded flow data permitted the calibration of roughness coefficients only for low channel flows. The selection of roughness coefficients was based on the review of aerial photographs, field reconnaissance, channel size and alignment, and channel and overbank ground cover (Reference 25). The channel and overbank "n" values for the streams studied by detailed methods are shown below:

Stream	Channel "n"	Overbank "n"
Taylors Bayou (A104-00-00)	0.035	0.020-0.150
Tributary 3.93 to Taylors Bayou (A104-07-00)	0.040-0.050	0.090-0.150
Armand Bayou (B100-00-00)	0.030-0.060	0.045-0.150
Horsepen Bayou (B104-00-00)	0.040-0.070	0.080-0.150
Big Island Slough (B106-00-00)	0.060	0.100-0.150
Spring Gully (B109-00-00)	0.035-0.045	0.090-0.150
Tributary 9.40 to Armand Bayou (B111-00-00)	0.055	0.090-0.150
Willow Springs Bayou (B112-00-00)	0.045	0.090-0.150

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Stream	Channel "n"	Overbank "n"
Tributary 10.46 to Armand Bayou (B113-00-00)	0.040-0.060	0.090-0.150
Tributary 12.18 to Armand Bayou (B115-00-00)	0.035	0.090-0.150
Buffalo Bayou (W100-00-00)	0.025	0.060-0.150
Glenmore Ditch (G108-00-00)	0.025-0.040	0.080-0.100
Tributary 6.77 to Buffalo Bayou	0.030	0.050
Tributary 8.17 to Buffalo Bayou	0.040	0.050
Vince Bayou (I100-00-00)	0.015-0.040	0.150
Little Vince Bayou (I101-00-00)	0.150	0.020-0.035

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding sources studied, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of the shorelines.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The COE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 26). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures. This criterion has been adopted by the FEMA for the determination of V-zones.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the NAS (Reference 23). The NAS methodology is based on three major concepts.

First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where H_b is the crest to trough height of the maximum or breaking wave and d is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S_* + 0.7H_* = S_* + 0.55d$$

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where Z_w is the wave crest elevation, S_* is the stillwater elevation at the site, and H_* is the wave height at the site. The 0.7 coefficient is the portion of the wave height which reaches above the stillwater elevation. H_b is the upper limit for H_*.

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man-made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

where H_t is the transmitted wave height, H_i is the incident wave height, and B is a transmission coefficient ranging from 0.0 to 1.0. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine B for vegetation, buildings, natural barriers such as dunes, and man-made barriers such as breakwaters and seawalls (Reference 23).

The third concept deals with unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

These concepts and equations were used to compute wave heights and wave crest elevations associated with the 100-year storm surge. Accurate topographic, land-use, and land cover data are required for the wave height analysis. Maps of the study area at a scale of 1:24,000 enlarged to a scale of 1:12,000 with a contour interval of 5 feet were used for the topographic data (Reference 24). The land-use and land cover data were obtained through aerial photographs (Reference 25).

Wave heights were computed along transects which were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 2 illustrates the location of the transects for the community.

Along each transect, wave heights and wave crest elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot

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increments along the transects. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the stillwater elevation or the coastal flooding met another flooding source (i. e. riverine) with an equal water-surface elevation. The results of the calculations are accurate until local topography, vegetation, or cultural development of the community undergo any major changes.

Figure 3 represents a sample transect which illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the A/V zone boundary.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps. It should be noted that elevations of these reference marks were established by the Galveston District of the COE based on the 1973 releveling performed by the National Geodetic Survey (NGS). In some cases, the 1973 elevation of an NGS benchmark established by the COE may not be in agreement with the 1973 elevation published by the NGS. In these cases, only the 1973 elevation established by the COE and shown on the Flood Insurance Rate Map should be used in determining elevations of structures in relation to the base flood elevations published in this report.

3.3 Land Subsidence

The prevalence of land subsidence in the study area complicates the determination of the expected depth of flooding at a property. This information should always be obtained by direct comparison of the current property elevation with the official base flood elevation at that property as shown on the Flood Insurance Rate Map and accompanying Flood Profiles (Sections 5.4 and 3.2, respectively).

A list of the elevation reference mark descriptions has been compiled for this study and the locations are shown on the maps to assist in determining property elevations. Care should be exercised in their use, since their listed elevations may not reflect current property elevations if subsidence has occurred since they were established.

Local officials should be aware of the subsidence problem and should require the use of the most up-to-date and accurate property elevation data in compensating for land subsidence; however, base flood elevations should not be adjusted, but obtained directly from the Flood Insurance Rate Map and accompanying profiles.

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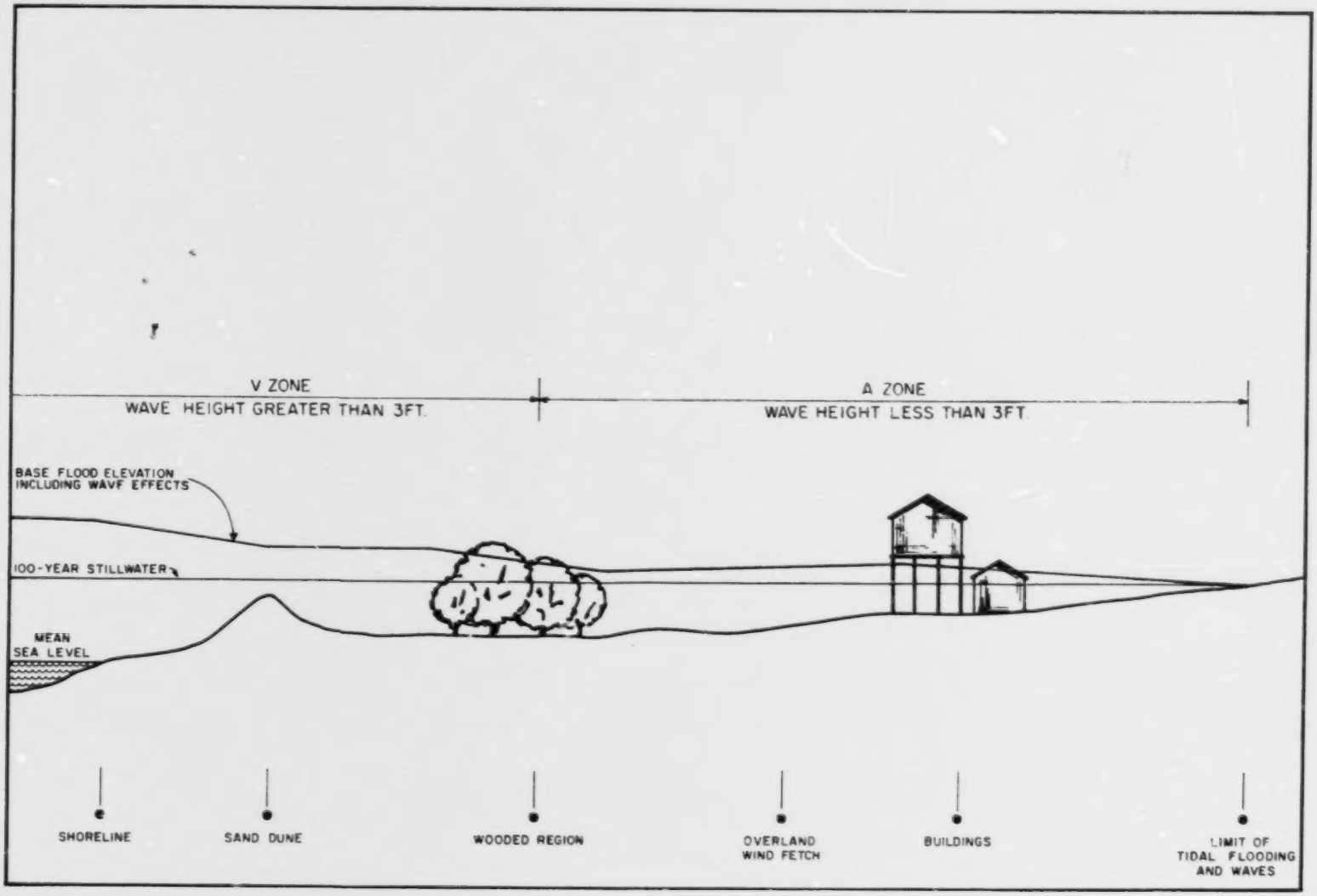

FIGURE 3
TYPICAL TRANSECT SCHEMATIC

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps (Reference 24).

For the areas studied by approximate methods, the boundary of the 100-year flood was delineated using HCFCD contour maps.

Flood boundaries are indicated on the Flood Insurance Rate Map. On this map, special flood hazard areas inundated by the 100-year flood which have additional hazards due to wave action have been designated as Zones V20, V21, A14, and A15. The 500-year boundary corresponds to the boundary of areas of moderate flood hazards (Zone B).

The A and V zones were subdivided into whole foot elevation zones based on the average wave crest elevation in that zone. Where the map scale did not permit delineating zones at one foot intervals, larger increments were used.

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of

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flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 3).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown. Portions of the floodway widths for Big Island Slough and Horsepen Bayou extend beyond the corporate limits.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 4.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 3 for certain downstream cross sections of Taylors Bayou, Tributary 3.93 to Taylors Bayou, Armand Bayou, Horsepen Bayou, Big Island Slough, Spring Gully, Tributary 9.40 to Armand Bayou, Willow Springs Bayou, Tributary 10.46 to Armand Bayou, Tributary 12.18 to Armand Bayou, Tributary 6.77 to Buffalo Bayou, Tributary 8.17 to Buffalo Bayou, and Little Vince Bayou are lower than the regulatory flood elevations in that area, which must take into account the 100-year flooding due to backwater from other sources.

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Taylors Bayou (A104-00-00) A	11,859	140	1,981	2.0	11.4[2]	6.7[3]	6.7	0.0

[1]Feet above confluence with Clear Creek (Clear Lake) (A100-00-00)

[2]Elevation computed using combined probability analysis

[3]Elevation computed without consideration of backwater from Clear Creek (Clear Lake) (A100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

TAYLORS BAYOU (A104-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Tributary 3.93 to Taylors Bayou (A104-07-00)								
A	9,187	100	251	2.6	11.4[2]	9.4[3]	9.4	0.0

[1]Feet above confluence with Taylors Bayou (A104-00-00)

[2]Elevation computed using combined probability analysis

[3]Elevation computed without consideration of backwater from Taylors Bayou (A104-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

Tributary 3.93 to Taylors Bayou (A104-07-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Armand Bayou (B100-00-00)								
A	2,481	1,803	10,894	2.1	11.4	3.5[3]	3.5	0.0
B	4,065	1,594	9,543	2.4	11.4	3.8[3]	3.8	0.0
C	7,339	1,400	8,625	2.7	11.4	4.9[3]	4.9	0.0
D	8,870	1,073	8,208	2.8	11.4	5.3[3]	5.3	0.0
E	11,035	1,288	8,756	2.7	11.4	5.7[3]	5.7	0.0
F	12,883	1,073	9,133	2.6	11.4	6.0[3]	6.0	0.0
G	13,886	645	5,228	4.5	11.4	6.2[3]	6.2	0.0
H	17,793	900	6,784	2.1	11.4	7.8	7.9	0.1
I	19,377	700	6,102	2.3	11.5[2]	8.2	8.3	0.1
J	21,067	700	6,671	2.1	11.5[2]	8.8	8.9	0.1
K	22,260	400	4,377	3.2	11.5[2]	9.6	9.6	0.0
L	27,118	640	4,880	2.1	11.7[2]	10.4	10.5	0.1
M	28,068	400	3,586	2.9	11.8[2]	10.7	10.9	0.2
N	31,606	400	4,688	2.2	12.5[2]	12.2	12.5	0.3
O	33,243	500	3,463	3.0	13.0[2]	12.9	13.3	0.4
P	34,088	500	4,617	2.3	13.7[2]	13.6	14.1	0.5
Q	34,160	500	5,249	1.9	13.9[2]	13.8	14.4	0.6
R	36,359	400	5,167	1.9	14.3[2]	14.2	15.0	0.8
S	38,049	1,030	8,572	1.0	14.6[2]	14.5	15.3	0.8
T	40,161	600	5,072	1.7	14.9[2]	14.8	15.6	0.8
U	42,642	700	6,0722	1.5	15.8[2]	15.7	16.6	0.9
V	45,651	500	4,636	1.9	16.7	16.7	17.7	1.0

[1]Feet above confluence with Clear Creek (Clear Lake) (A100-00-00)
[2]Elevation computed using combined probability analysis
[3]Elevation computed without consideration of backwater from Clear Creek (Clear Lake) (A100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

ARMAND BAYOU (B100-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Armand Bayou (B100-00-00) (continued)								
W	48,291	500	3,681	2.4	18.1	18.1	19.1	1.0
X	49,347	500	4,142	2.1	18.5	18.5	19.5	1.0
Y	51,512	1,000	5,029	1.6	19.6	19.6	20.5	0.9
Z	53,255	860	5,103	1.5	20.7	20.7	21.7	1.0
AA	54,786	1,300	5,980	0.8	21.4	21.4	22.4	1.0
AB	57,373	970	5,062	0.7	21.9	21.9	22.9	1.0
AC	58,799	210	1,144	3.0	22.4	22.4	23.4	1.0
AD	60,330	415	2,269	1.3	24.0	24.0	25.0	1.0
AE	61,438	103	752	3.7	24.9	24.9	25.6	0.7
AF	63,022	250	1,327	1.9	25.8	25.8	26.6	0.8
AG	64,025	65	656	3.4	26.0	26.0	26.9	0.9
AH	65,609	88	626	1.8	26.5	26.5	27.4	0.9
AI	66,612	55	429	2.6	26.7	26.7	27.6	0.9
AJ	68,539	125	588	1.6	27.1	27.1	28.0	0.9
AK	68,645	125	550	1.7	27.1	27.1	28.0	0.9
AL	69,279	200	557	1.5	27.3	27.3	28.3	1.0
AM	70,414	40	226	3.5	27.9	27.9	28.9	1.0
AN	71,866	291	565	1.2	29.6	29.6	30.6	1.0

[1]Feet above confluence with Clear Creek (Clear Lake) (A100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

ARMAND BAYOU (B100-00-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Horsepen Bayou (B104-00-00)								
A	2,112	600	3,758	2.2	11.4[3]	5.7[4]	5.8	0.1
B	4,382	230	1,654	5.1	11.5[3]	9.3	9.8	0.5
C	6,072	360	3,690	2.3	12.5[3]	12.3	13.2	0.9
D	7,708	385	4,065	2.1	13.7[3]	13.6	14.5	0.9
E	8,288	540	4,091	2.1	14.4[3]	14.3	15.2	0.9
F	8,580	275	3,745	2.1	14.7[3]	14.7	15.6	0.9
G	9,715	300/30[2]	3,727	2.1	15.1[3]	15.1	16.0	0.9
H	10,308	241/21[2]	2,404	3.2	15.5[3]	15.4	16.3	0.9
I	10,876	200/0[2]	2,778	2.8	16.0[3]	16.0	16.8	0.8
J	11,616	152/0[2]	2,139	3.6	16.3[3]	16.2	17.1	0.9
K	11,774	169/0[2]	2,260	3.5	16.3[3]	16.2	17.1	0.9
Big Island Slough (B106-00-00)								
A	1,584	123	1,146	4.3	11.7[3]	7.3[4]	8.0	0.7
B	3,115	149	1,467	3.4	11.7[3]	9.3[4]	9.9	0.6
C	4,329	149	1,579	3.1	11.7[3]	10.5[4]	11.0	0.5
D	5,390	180	1,764	2.8	11.9[3]	11.3	11.7	0.4
E	15,363	146/73[2]	1,436	2.6	16.3	16.3	16.4	0.1
F	16,472	182/91[2]	1,776	2.0	16.7	16.7	16.8	0.1
G	17,581	236/118[2]	1,965	1.8	17.0	17.0	17.1	0.1
H	18,690	178/89[2]	1,824	1.7	17.3	17.3	17.4	0.1

[1]Feet above confluence with Armand Bayou (B100-00-00)

[2]Width/width within corporate limits

[3]Elevation computed using combined probability analysis

[4]Elevation computed without consideration of backwater from Armand Bayou (B100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

HORSE PEN BAYOU (B104-00-00)—BIG ISLAND SLOUGH (B106-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Spring Gully (B109-00-00) A	1,161	120	202	9.4	14.6[2]	7.0[3]	7.0	0.0

[1]Feet above confluence with Armand Bayou (B100-00-00)

[2]Elevation computed using combined probability analysis

[3]Elevation computed without consideration of backwater from Armand Bayou (B100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

SPRING GULLY (B109-00-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Tributary 9.40 to Armand Bayou (B111-00-00)								
A	813	49	155	8.9	18.7	12.2[2]	12.2	0.0
B	1,077	100	535	2.6	18.7	15.4[2]	15.4	0.0
Willow Springs Bayou (B112-00-00)								
A	958	150	896	4.4	21.0	12.7[2]	12.7	0.0
B	1,108	180	670	5.9	21.0	12.8[2]	12.8	0.0
C	1,372	180	498	7.9	21.0	13.3[2]	13.3	0.0
Tributary 10.46 to Armand Bayou (B113-00-00)								
A	2,006	140	260	4.8	21.7	20.9[2]	20.9	0.0
B	3,405	117	418	2.8	22.8	22.8	23.4	0.6
C	5,808	58	345	2.9	24.8	24.8	25.1	0.3
D	7,841	60	275	3.3	26.4	26.4	26.5	0.1
E	8,554	90	402	2.1	27.0	27.0	27.1	0.1
F	10,049	55	253	3.1	27.8	27.8	27.9	0.1
G	11,263	54	262	2.8	28.8	28.8	28.9	0.1

[1]Feet above confluence with Armand Bayou (B100-00-00)
[2]Elevation computed without consideration of backwater from Armand Bayou (B100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

Tributary 9.40 to Armand Bayou (B111-00-00)—Willow Springs Bayou (B112-00-00)–Tributary 10.46 to Armand Bayou (B113-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Tributary 12.18 to Armand Bayou (B115-00-00)								
A	765	91	494	4.9	26.1	25.7[2]	26.6	0.9
B	2,164	109	530	4.0	27.5	27.5	28.0	0.5
C	4,223	73	584	3.1	28.8	28.8	29.1	0.3
D	6,335	74	602	2.5	29.5	29.5	29.8	0.3
E	7,397	72	519	2.7	29.7	29.7	30.0	0.3
F	7,667	72	559	2.5	29.8	29.8	30.1	0.3

[1]Feet above confluence with Armand Bayou (B100-00-00)

[2]Elevation computed without consideration of backwater from Armand Bayou (B100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

Tributary 12.18 to Armand Bayou (B115-00-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Glenmore Ditch (G108-00-00)								
A	1,733	87/0[2]	784	3.2	17.9[3]	17.8	17.9	0.1
B	3,951	104	698	3.4	18.6[3]	18.5	19.0	0.5
C	5,751	98	698	3.3	19.8[3]	19.7	20.0	0.3
D	8,550	70	416	4.7	23.0	23.0	23.1	0.1
E	9,237	70	420	4.5	24.1	24.1	24.2	0.1
F	11,138	50	372	4.6	26.5	26.5	26.7	0.2
G	12,299	62	331	4.8	28.5	28.5	28.6	0.1
H	12,669	62	274	4.7	28.8	28.8	28.9	0.1

[1]Feet above confluence with Buffalo Bayou (W100-00-00)

[2]Width/width within corporate limits

[3]Elevation computed using combined probability analysis

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

Glenmore Ditch (G108-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Tributary 6.77 to Buffalo Bayou								
A	0.570[1]	1,095	1,117	0.4	12.0[3]	8.3[4]	9.2	0.9
B	0.656[1]	120	282	1.6	12.0[3]	8.7[4]	9.5	0.8
Tributary 8.17 to Buffalo Bayou								
A	0.97[1]	70	237	0.6	11.8[3]	5.1[4]	6.1	1.0
Vince Bayou (I100-00-00)								
A	3,860[2]	200	2,211	4.6	11.9[3]	10.9	11.5	0.6
B	4,450[2]	180	2,009	5.0	12.6[3]	12.2	12.7	0.5
C	5,479[2]	125	1,598	6.2	13.2[3]	13.0	13.6	0.6
D	5,719[2]	280	2,735	3.6	13.5[3]	13.3	14.2	0.9
E	5,998[2]	175	2,004	4.9	13.6[3]	13.4	14.3	0.9
F	6,325[2]	150	1,951	5.0	14.5[3]	14.4	14.8	0.4
G	7,085[2]	200	1,997	4.9	15.4[3]	15.3	15.6	0.3
H	7,656[2]	125	1,887	5.2	15.6[3]	15.6	16.2	0.6
I	8,184[2]	130	1,590	6.1	15.9[3]	15.8	16.5	0.7
J	8,310[2]	125	1,463	6.6	16.1[3]	16.0	16.5	0.5
K	9,342[2]	120	1,547	5.8	17.4[3]	17.3	17.8	0.5
L	10,978[2]	600	4,260	2.0	18.2[3]	18.1	18.8	0.7
M	11,508[2]	167	1,696	5.0	18.2	18.2	18.8	0.6

[1]Miles above confluence with Buffalo Bayou (W100-00-00)
[2]Feet above confluence with Buffalo Bayou (W100-00-00)
[3]Elevation computed using combined probability analysis
[4]Elevation computed without consideration of backwater from Buffalo Bayou (W100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

Tributary 6.77 to Buffalo Bayou—Tributary 8.17 to Buffalo Bayou—Vince Bayou (I100-00-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Vince Bayou (I100-00-00) (continued)								
N	12,307	81	687	12.2	20.8	20.8	20.8	0.0
O	13,607	86	666	12.6	21.8	21.8	21.9	0.1
P	13,867	86	899	8.5	24.4	24.4	24.5	0.1
Q	15,157	90	741	10.3	24.6	24.6	24.7	0.1
R	16,732	80	721	9.4	26.0	26.0	26.0	0.0
S	17,157	108	825	7.4	27.2	27.2	27.2	0.0
T	17,928	80	944	6.1	28.2	28.2	28.2	0.0
U	18,798	113	972	5.9	28.6	28.6	28.6	0.0
V	19,798	87	716	7.2	29.0	29.0	29.0	0.0
W	20,896	92	1,077	4.3	29.9	29.9	30.0	0.1
X	20,948	92	1,114	4.1	30.3	30.3	30.4	0.1
Y	23,058	119	1,116	4.1	31.3	31.3	31.4	0.1
Z	25,628	85	951	3.2	32.6	32.6	32.6	0.0
AA	26,668	100	990	2.6	32.9	32.9	32.9	0.0
AB	28,028	91	884	2.6	33.2	33.2	33.3	0.1
AC	28,548	110	948	2.4	33.4	33.4	33.5	0.1
AD	28,875	106	957	2.2	33.5	33.5	33.6	0.1
AE	29,806	81	656	2.9	33.8	33.8	33.9	0.1
AF	30,378	90	660	2.7	34.1	34.1	34.2	0.1
AG	31,378	100	677	2.5	34.5	34.5	34.6	0.1

[1]Feet above confluence with Buffalo Bayou (W100-00-00)

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TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

VINCE BAYOU (I100-00-00)

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Little Vince Bayou (I101-00-00)								
A	2,069	100	763	3.7	11.9[2]	11.0[3]	11.1	0.1
B	2,219	100	773	3.6	11.9[2]	11.1[3]	11.2	0.1
C	2,719	41	401	6.9	11.9[2]	11.3[3]	11.4	0.1
D	2,931	366	1,193	2.3	12.8[2]	12.7	12.8	0.1
E	3,933	41	463	5.7	13.6[2]	13.5	14.0	0.5
F	4,568	85	611	4.3	14.8[2]	14.7	15.1	0.4
G	5,568	65	343	7.7	16.6[2]	16.6	16.8	0.2
H	5,938	29	295	9.0	17.9[2]	17.8	17.8	0.0
I	6,337	102	353	7.1	19.3	19.3	19.4	0.1
J	6,646	70	309	8.2	19.4	19.4	19.4	0.0
K	6,869	62	306	8.1	20.3	20.3	20.3	0.0
L	7,070	50	316	7.8	21.1	21.1	21.1	0.0
M	7,230	60	356	6.8	22.0	22.0	22.0	0.0
N	7,915	75	545	4.5	23.6	23.6	23.6	0.0
O	8,706	48	383	6.1	24.7	24.7	24.7	0.0
P	9,496	600	1,393	1.7	25.9	25.9	26.1	0.2
Q	10,131	600	1,717	1.3	26.3	26.3	26.7	0.4
R	11,419	800	1,671	1.4	27.0	27.0	27.6	0.6
S	12,264	800	2,090	1.0	27.6	27.6	28.1	0.5
T	13,215	800	2,164	0.8	28.0	28.0	28.7	0.7
U	14,420	580	1,142	1.5	28.7	28.7	29.6	0.9

[1]Feet above confluence with Vince Bayou (I100-00-00)

[2]Elevation computed using combined probability analysis

[3]Elevation computed without consideration of backwater from Vince Bayou (I100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

LITTLE VINCE BAYOU (I 101-00-00)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD-1973 RELEVELING)			
Little Vince Bayou (I101-00-00) (continued)								
V	15,053	400	794	2.0	29.5	29.5	30.0	0.5
W	15,474	56	437	2.8	29.8	29.8	30.6	0.8
X	15,948	50	342	3.6	30.1	30.1	30.8	0.7
Y	16,318	42	358	3.2	30.4	30.4	31.0	0.6
Z	17,103	280	1,152	0.9	30.6	30.6	31.3	0.7
AA	17,873	280	1,104	0.9	30.6	30.6	31.4	0.8
AB	18,647	50	290	3.4	30.9	30.9	31.6	0.7
AC	19,167	41	293	3.2	31.2	31.2	32.0	0.8
AD	20,111	32	232	3.8	31.7	31.7	32.6	0.9
AE	20,641	45	252	3.5	32.2	32.2	33.0	0.8
AF	21,591	36	191	4.2	33.2	33.2	34.0	0.8

[1]Feet above confluence with Vince Bayou (I100-00-00)

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOODWAY DATA

LITTLE VINCE BAYOU (I 101-00-00)

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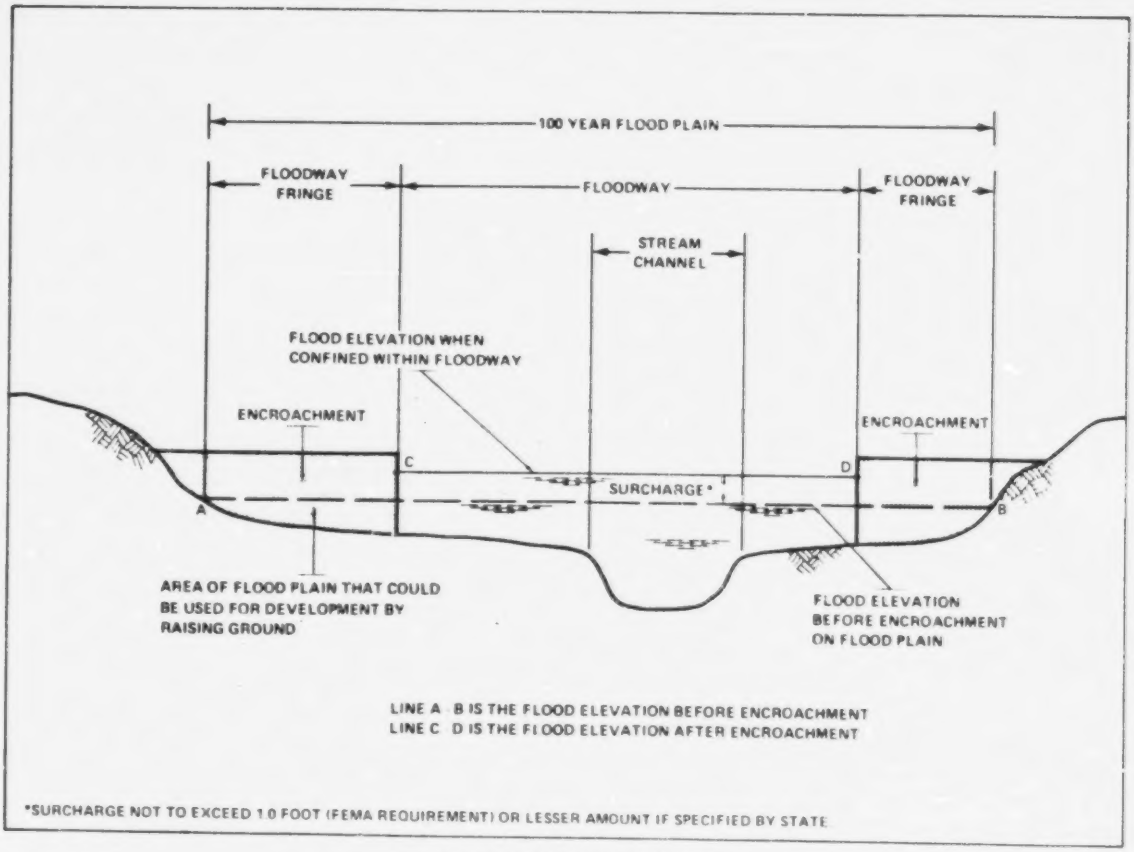
100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

FLOODWAY SCHEMATIC

Figure 4

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail in the City of Pasadena.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following tabulation for more than 20 percent of the reach:

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Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the City of Pasadena are shown on the Flood Profiles (Exhibit 1) and summarized in Table 4A.

In tidal areas, where no wave height analysis was performed, reaches are limited to the distance for which the difference between the 10- and 100-year flood elevations does not vary more than 1.0 foot. Using these criteria, the Buffalo Bayou shoreline above the northwestern corporate limits, Forrest Lake and a portion of Armand Bayou, Taylor Lake and Taylors Bayou, and portions of Horsepen Bayou, Big Island Slough, Glenmore Ditch, Vince Bayou, and Little Vince Bayou each qualify as a reach whose flooding source is Galveston Bay. The reaches determined for the tidal flooding sources in the City of Pasadena are summarized in Table 4A, "Flood Insurance Zone Data".

In areas where a wave height analysis was performed, reaches were determined for areas of the coastline, represented by a transect or group of transects, which have similar physical characteristics. The locations of these transects are shown on the Transect Location Map (Figure 2) and are summarized in Table 4B, "Flood Insurance Zone Data".

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD-1973 RELEVELING)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Taylors Bayou (A104-00-00)							
Reach 1*	20	-6.2	-1.7	+3.3	060	A12	11
Armand Bayou (B100-00-00)							
Reach 1*	20	-4.2	-1.5	+3.2	040	A8	Varies
Reach 2*	15,20	-2.1	-0.6	+1.5	020	A4	Varies
Reach 3	15	-1.4	-0.4	+0.8	015	A3	Varies
Horsepen Bayou (B104-00-00)							
Reach 1*	20	-2.8	-0.9	+1.9	030	A6	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

*Combined surge and riverine elevations

TABLE 4A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOOD INSURANCE ZONE DATA

TAYLORS BAYOU (A104-00-00)-ARMAND BAYOU (B100-00-00)-HORSEPEN BAYOU (B104-00-00)

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD 1973 RELEVELING)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Big Island Slough (B106-00-00)							
Reach 1*	15,20	-2.6	-0.6	+1.7	025	A5	Varies
Reach 2	15	-2.4	-0.7	+1.1	025	A5	Varies
Tributary 10.46 to Armand Bayou (B113-00-00)							
Reach 1	15	-1.6	-0.5	+0.6	015	A3	Varies
Tributary 12.18 to Armand Bayou (B115-00-00)							
Reach 1	15	-1.4	-0.4	+0.7	015	A3	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

*Combined surge and riverine elevations

TABLE 4A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOOD INSURANCE ZONE DATA

BIG ISLAND SLOUGH (B106-00-00)-TRIBUTARY 10.46 TO ARMAND BAYOU (B113-00-00)-TRIBUTARY 12.18 TO ARMAND BAYOU (B115-00-00)

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD-1973 RELEVELING)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Buffalo Bayou (W100-00-00)							
Reach 1*	05	-6.3	-1.6	+3.5	065	A13	12
Glenmore Ditch (G108-00-00)							
Reach 1*	05	-3.3	-0.9	+1.9	035	A7	Varies
Reach 2	05	-3.0	-0.8	+1.7	030	A6	Varies
Vince Bayou (I100-00-00)							
Reach 1*	05	-2.7	-1.0	+1.4	025	A5	Varies
Reach 2	05,10	-2.7	-1.5	+1.1	025	A5	Varies
Little Vince Bayou (I101-00-00)							
Reach 1*	05	-1.6	-0.4	+2.5	015	A3	Varies
Reach 2	05	-1.3	-0.3	+0.8	015	A3	Varies
Reach 3	05	-0.4	-0.1	+0.3	005	A1	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

*Combined surge and riverine elevations

TABLE 4A

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX

(HARRIS CO.)

FLOOD INSURANCE ZONE DATA

BUFFALO BAYOU (W100-00-00)-GLENMORE DITCH (G108-00-00)-VINCE BAYOU (I100-00-00)
LITTLE VINCE BAYOU (I101-00-00)

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FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

APPROXIMATE SCALE
1500 0 1500 3000 4500 FEET

TRANSECT LOCATION MAP

FIGURE 2

TABLE 4B - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	Stillwater Elevation 100-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Clear Creek (Clear Lake) (A100-00-00)					
Transect 1	4.8	11.4	100	V20	14-15
			070	A14	11-13
Transect 2	4.8	11.4	100	V20	14-15
			075	A15	11-13
Transect 3	4.8	11.3	100	V20	14-15
			075	A15	11-13
Galveston Bay					
Transect 4	5.3	11.8	100	V20	14-18
			070	A14	12-14
Transect 5	5.3	11.8	100	V20	14-18
			070	A14	12-14
Transect 6	5.3	12.1	110	V21	14-17
			075	A15	12-14
Forrest Lake					
Transect 2	4.8	11.4	075	A15	11-13
			065	A13	11

*Due to map scale limitations, base flood elevations shown on the FIRM may represent average elevations for the zones depicted.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.

Zones A1, A2, A3, A4, A5, A6, A7, A8, A12, A13, A14, and A15: Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.

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Zones V20 and V21: Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater with base flood elevations shown, and zones subdivided according to FHFs.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding; not subdivided.

Flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the community are shown in Tables 4A and 4B.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Pasadena is, for insurance purposes, the principal result of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the National Flood Insurance Program.

6.0 OTHER STUDIES

The Pasadena Flood Insurance Study was conducted as a part of an overall study for the unincorporated areas of Harris County; therefore, the results of this study are in exact agreement with the results of the Harris County study (Reference 27). Flood Insurance Studies for the Cities of Houston, Deer Park, El Lago, and LaPorte have been prepared (References 28, 29, 30, and 31). The results of those studies are in exact agreement with the results of this study. The Flood Insurance Studies for the Cities of Seabrook, Shoreacres, and Taylor Lake Village have also been prepared (References 32, 33, and 34). The results of those studies are not in exact agreement with the results of

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this study due to the more recent hydrologic and hydraulic analyses and/or more recent topographic information used for this study.

The Flood Insurance Study for the City of South Houston is currently being prepared (Reference 35). The results of that study will be in complete agreement with the results of this study.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Regional Director, Region VI Office, Federal Center, Denton, Texas 76201.

8.0 BIBLIOGRAPHY AND REFERENCES

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ELEVATION IN FEET (NGVD 1973 releveling)

-15 -10 -5 0 5 10 15

6 8 10 12 14 16 18 20 22 24

STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH CLEAR CREEK (CLEAR LAKE) (A100-00-00)

TAYLOR LAKE

CORPORATE LIMITS

CONFLUENCE OF TRIBUTARY B 93 (A104-04-00)

CONFLUENCE OF TRIBUTARY B 35 (A104-13-00)

HARRIS COUNTY (AREA NOT INCLUDED)

CONFLUENCE OF TRIBUTARY B 93 (A104-07-00)

CORPORATE LIMITS

LIMIT OF FLOODING AFFECTING COMMUNITY

CORPORATE LIMITS

REDBLUFF ROAD

COMBINED PROBABILITY

REACH 1

ZONE AH

SOUTHERN PACIFIC RAILROAD

PORT ROAD

SOUTHERN PACIFIC RAILROAD

STATE ROUTE 146

CORPORATE LIMITS

LEGEND

500 YEAR FLOOD

100 YEAR FLOOD

50 YEAR FLOOD

10 YEAR FLOOD

STREAM BED

CROSS SECTION LOCATION

-10 -5 0 5 10 15

01P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

TAYLORS BAYOU (A104-00-00)

47

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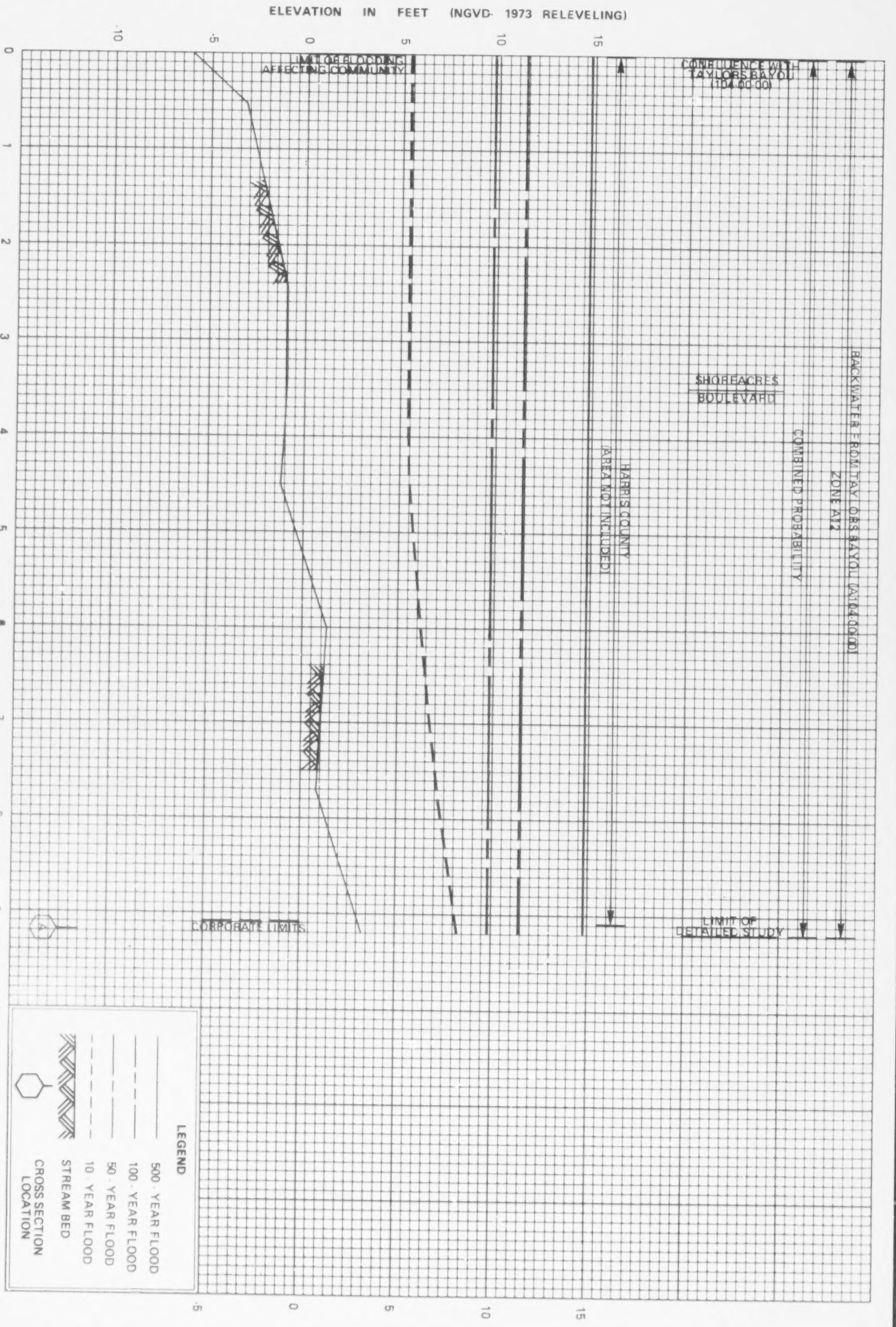

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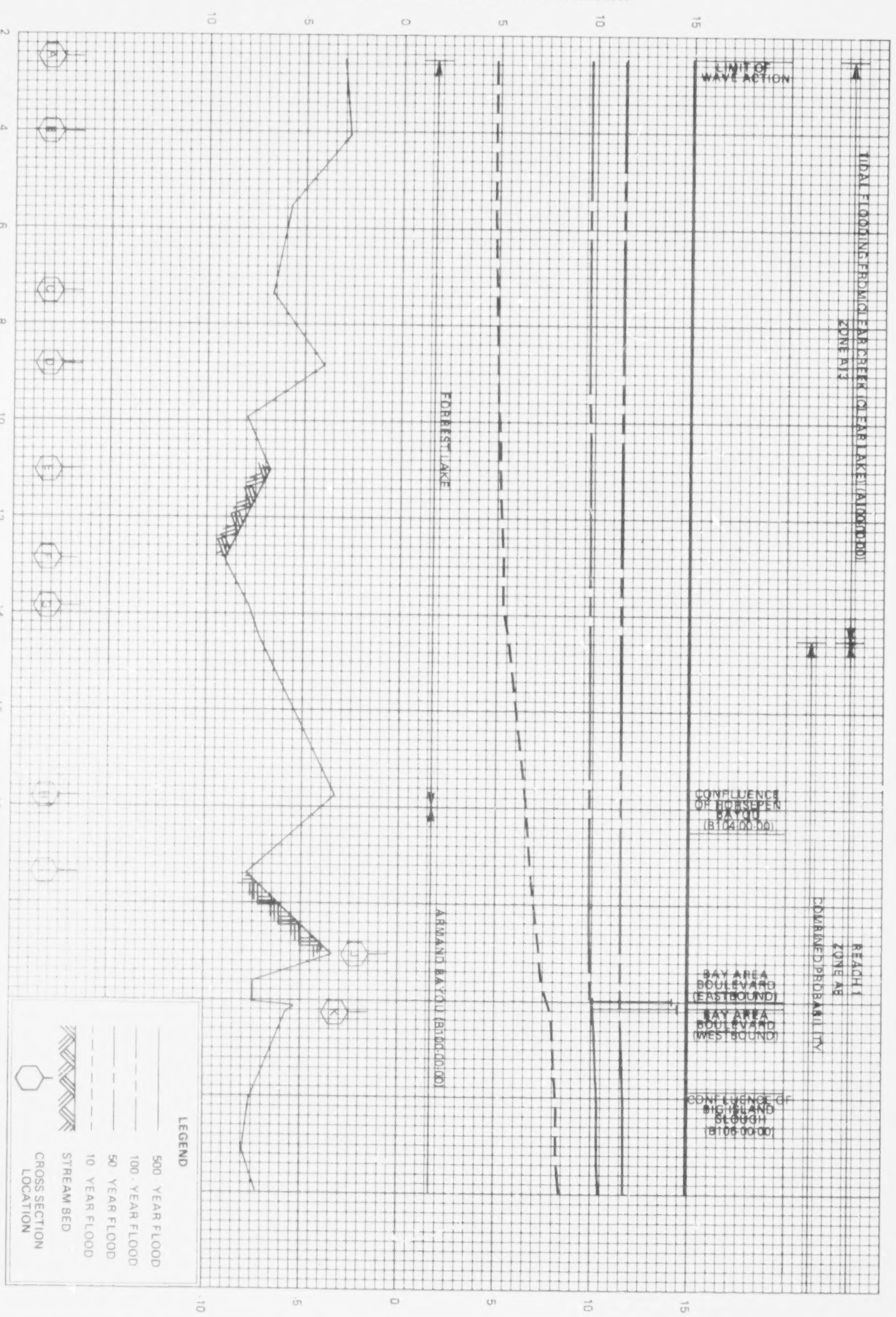

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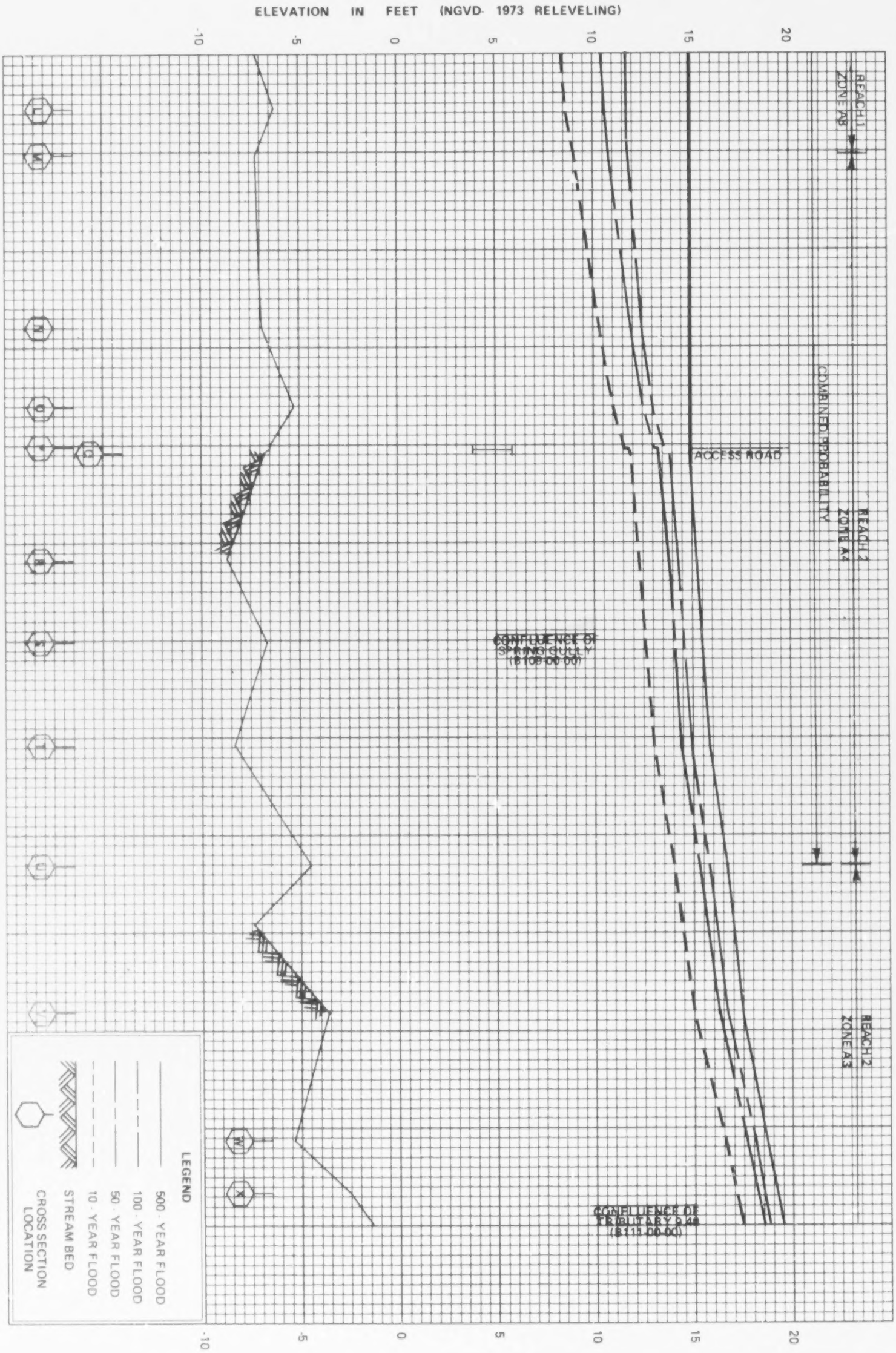

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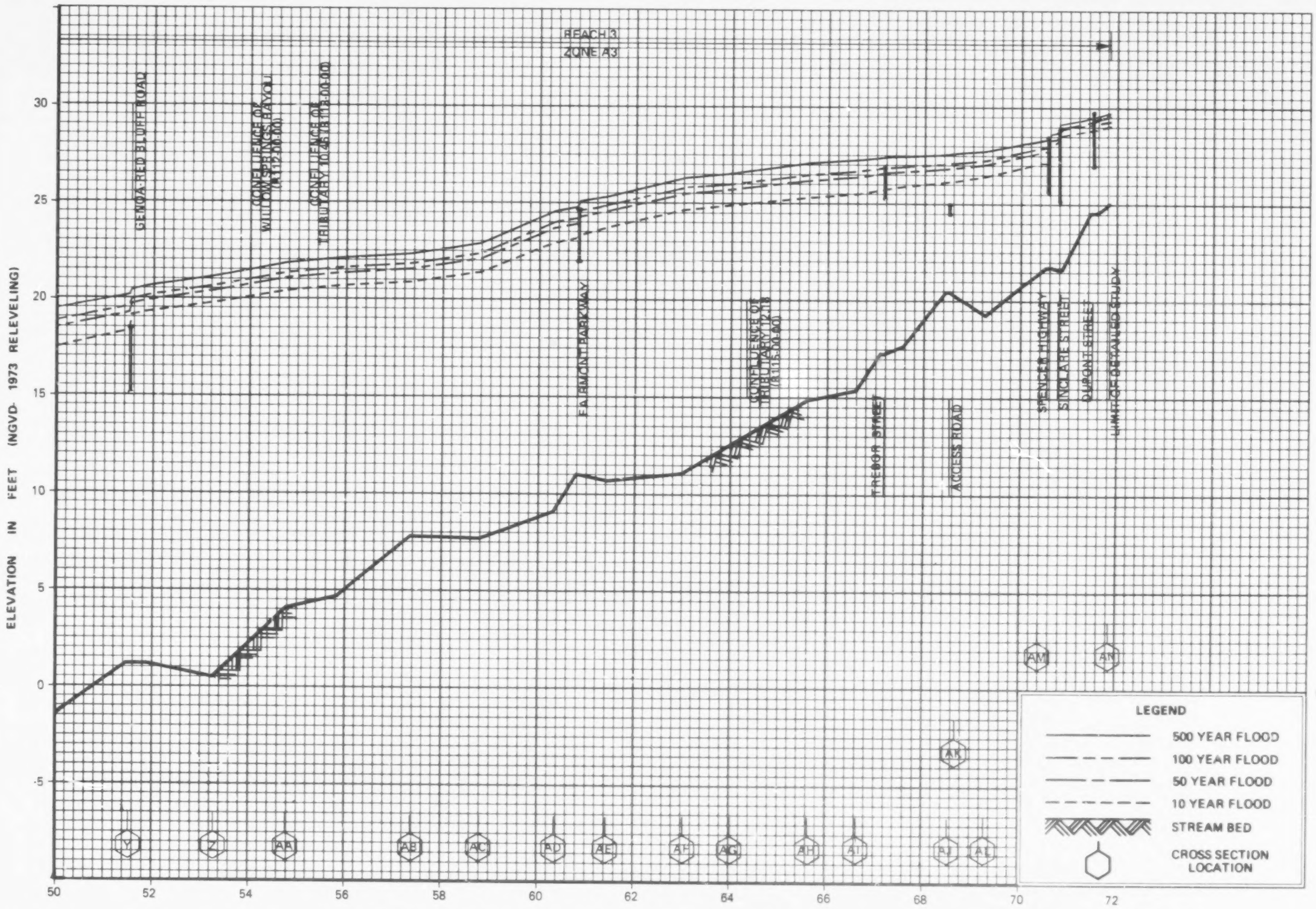


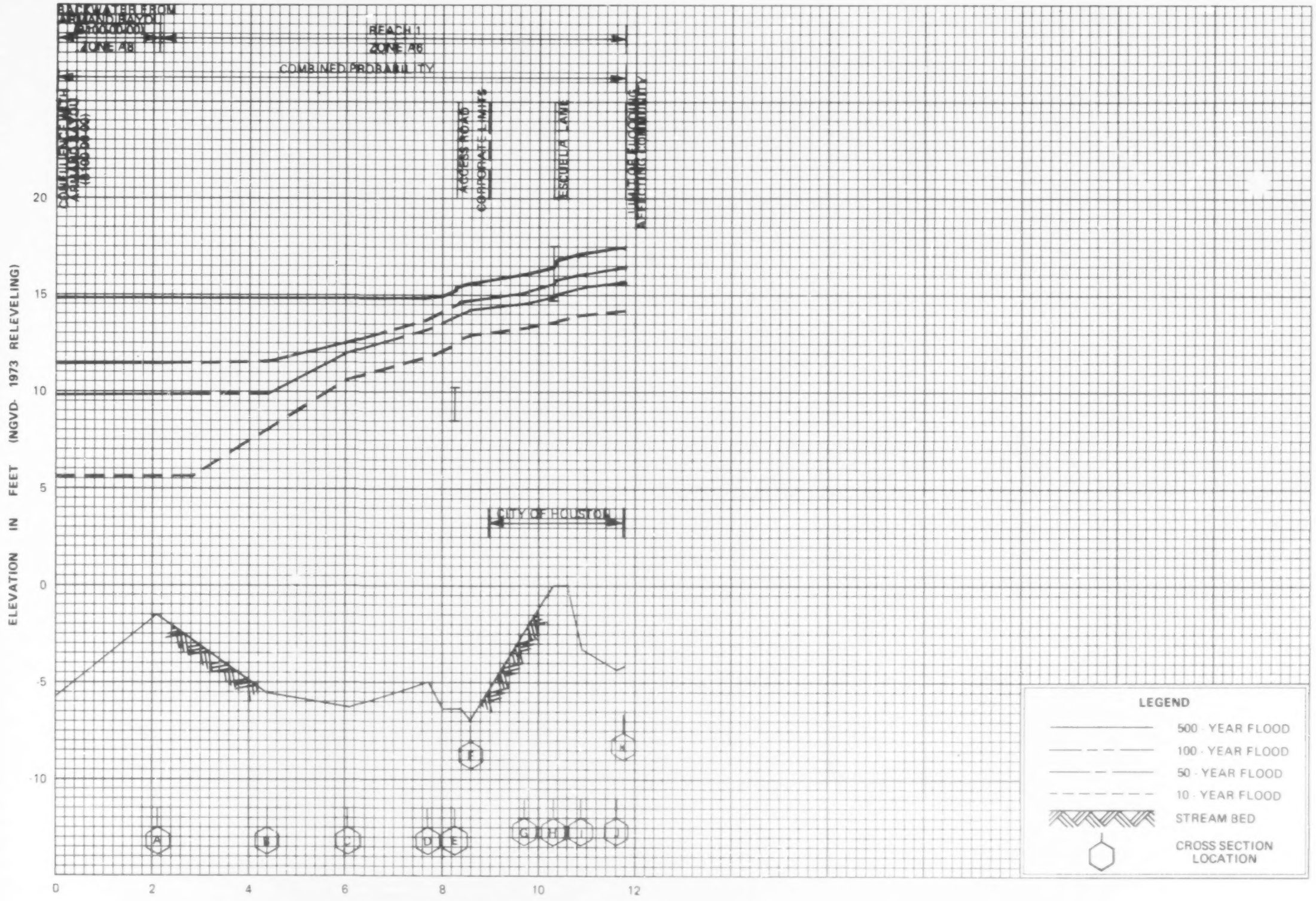
FLOOD PROFILES

ARMAND BAYOU (B100-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

05P



FLOOD PROFILES

HORSEPEN BAYOU (B104-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

06P

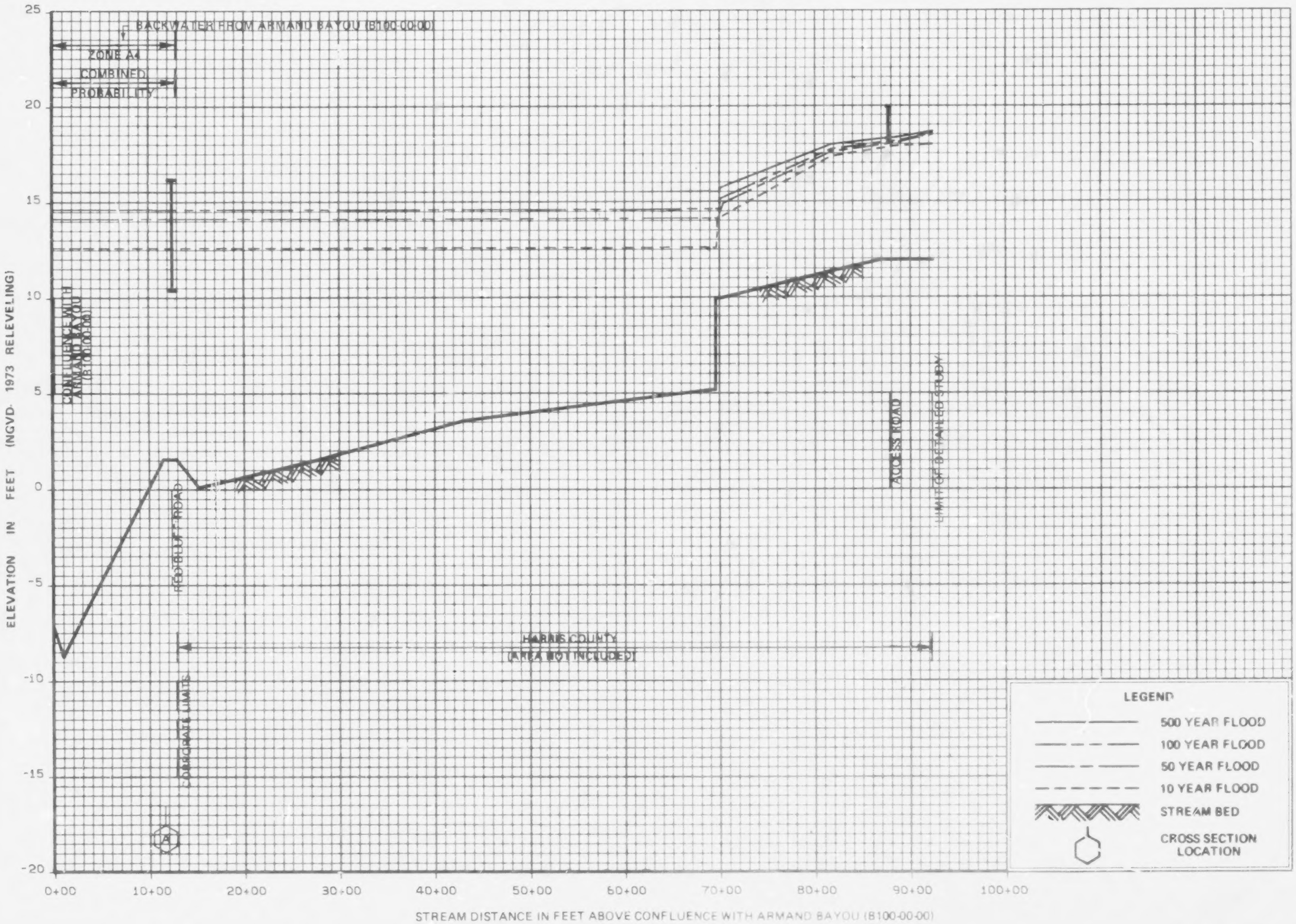
07P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

BIG ISLAND SLOUGH (B106-00-00)



FLOOD PROFILES

SPRING GULLY (B109-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

08P

ELEVATION IN FEET (NGVD 1973 releveling)

-5 0 5 10 15 20

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5

STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH ARMAND BAYOU (B100-00-00)

CONFLUENCE WITH ARMAND BAYOU (B100-00-00)

ACCESS ROAD

BACKWATER FROM ARMAND BAYOU (B100-00-00)

ZONE A1

CORPORATE LIMITS

A

A1

B

B1

LEGEND

500 - YEAR FLOOD

100 - YEAR FLOOD

50 - YEAR FLOOD

10 - YEAR FLOOD

STREAM BED

CROSS SECTION LOCATION

-5 0 5 10 15 20

55

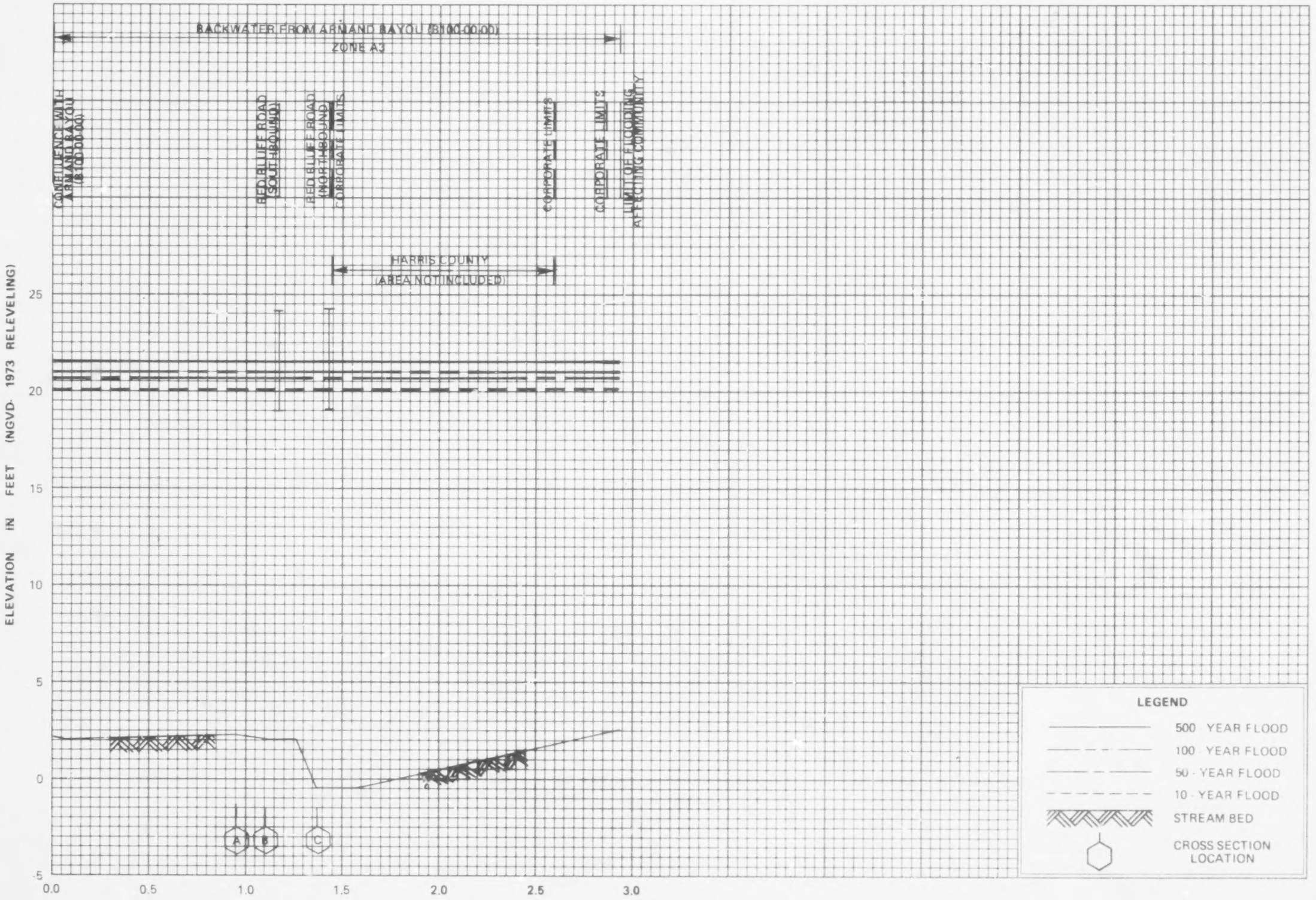
09P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

TRIBUTARY 9.40 TO ARMAND BAYOU (B111-00-00)



STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH ARMAND BAYOU (B100-00-00)

FLOOD PROFILES

WILLOW SPRINGS BAYOU (B112-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

10P

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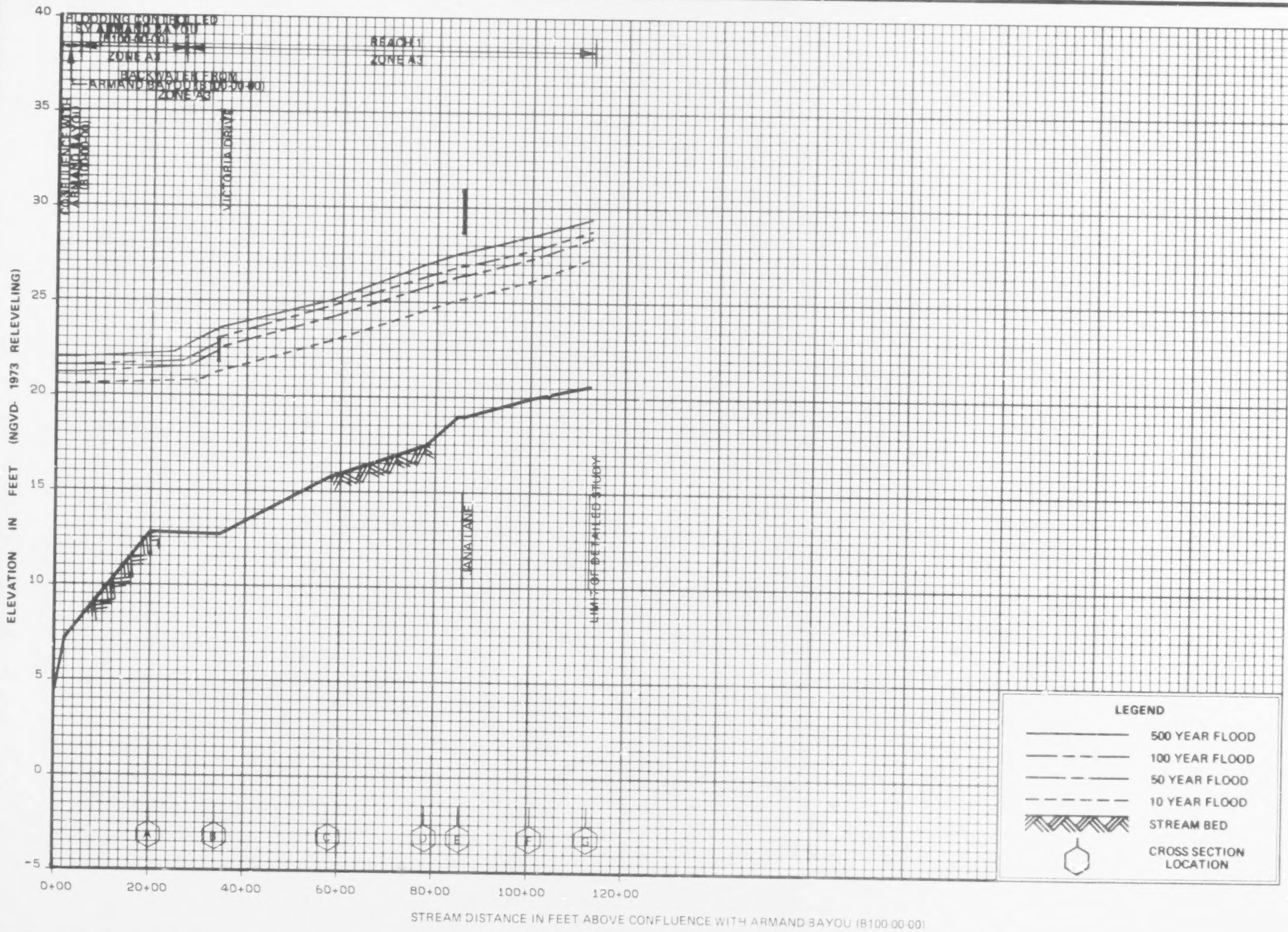


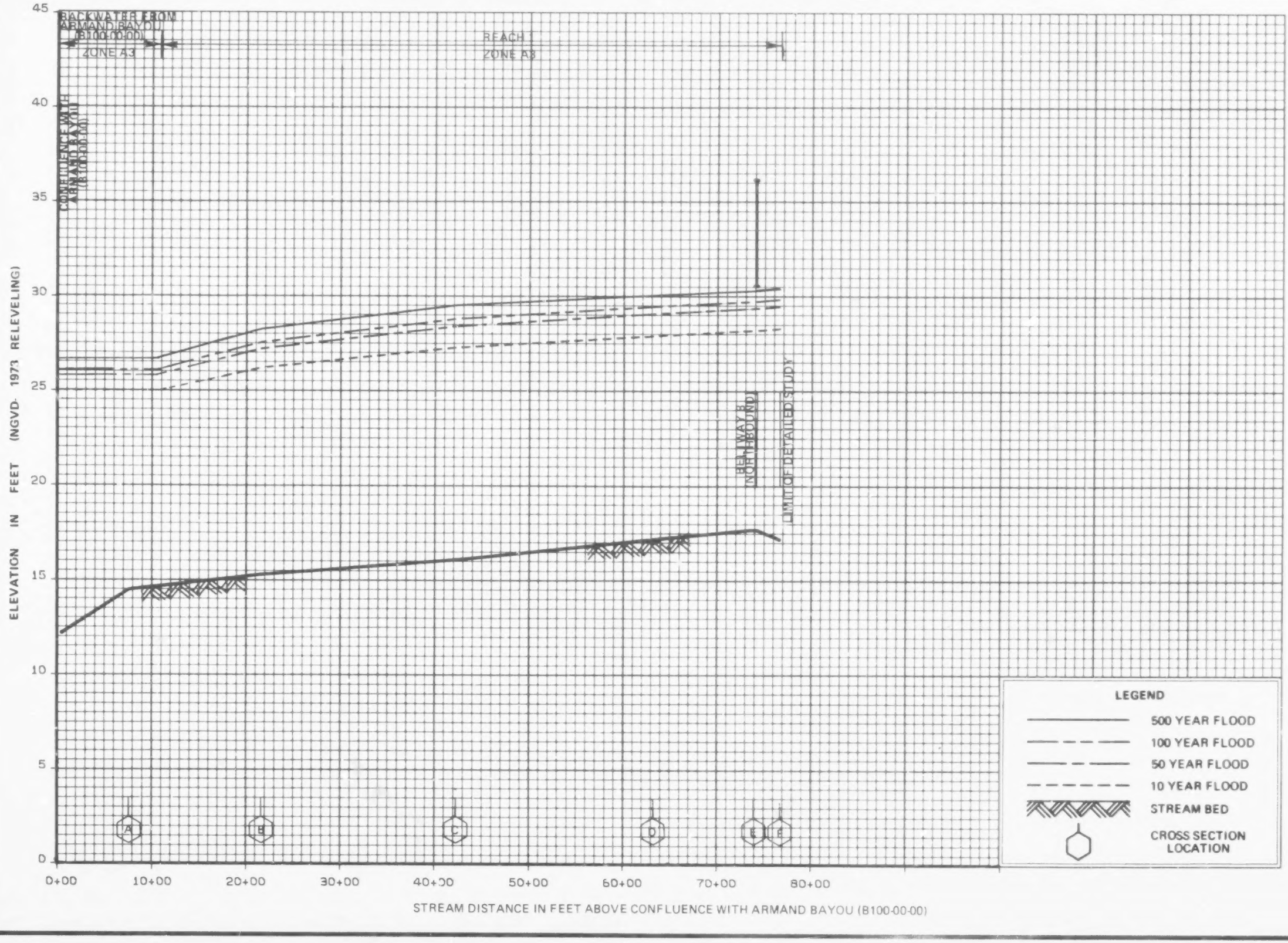
FLOOD PROFILES

TRIBUTARY 10.46 TO ARMAND BAYOU (B113-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

11P



FLOOD PROFILES

TRIBUTARY 12.18 TO ARMAND BAYOU (B115-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

12P

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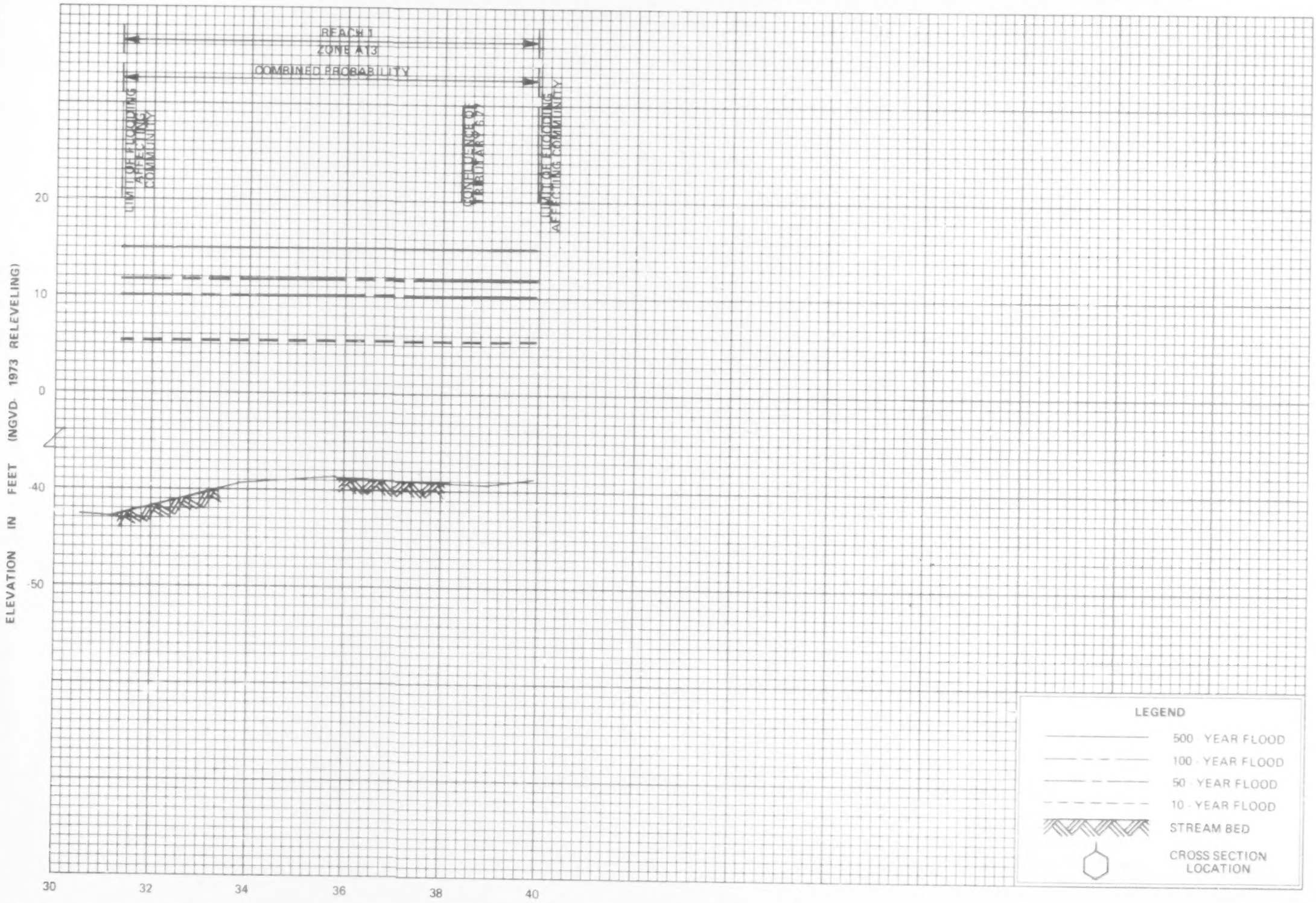

FLOOD PROFILES

BUFFALO BAYOU (W100-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

13P

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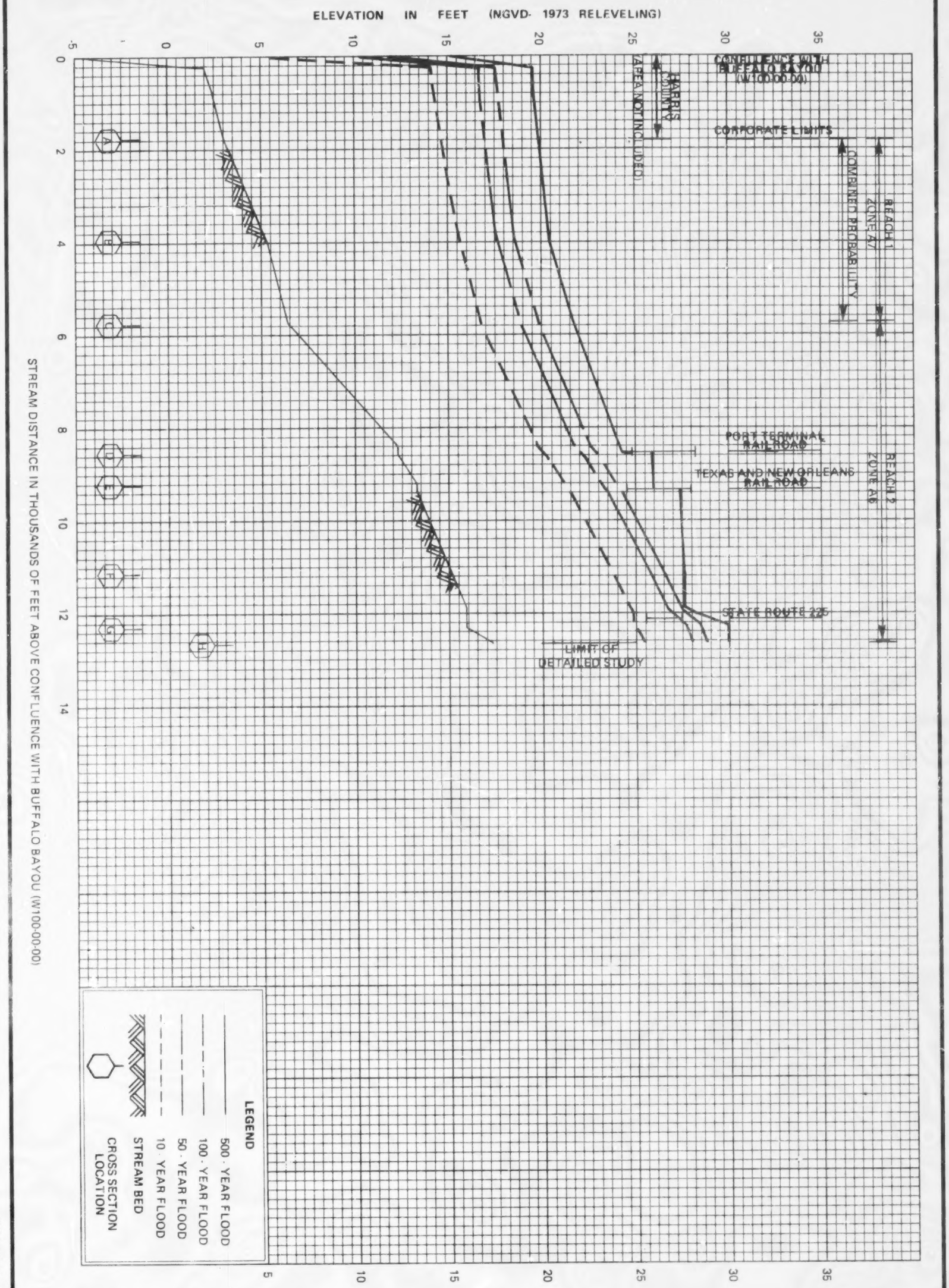

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

GLENMORE DITCH (G108-00-00)

14P

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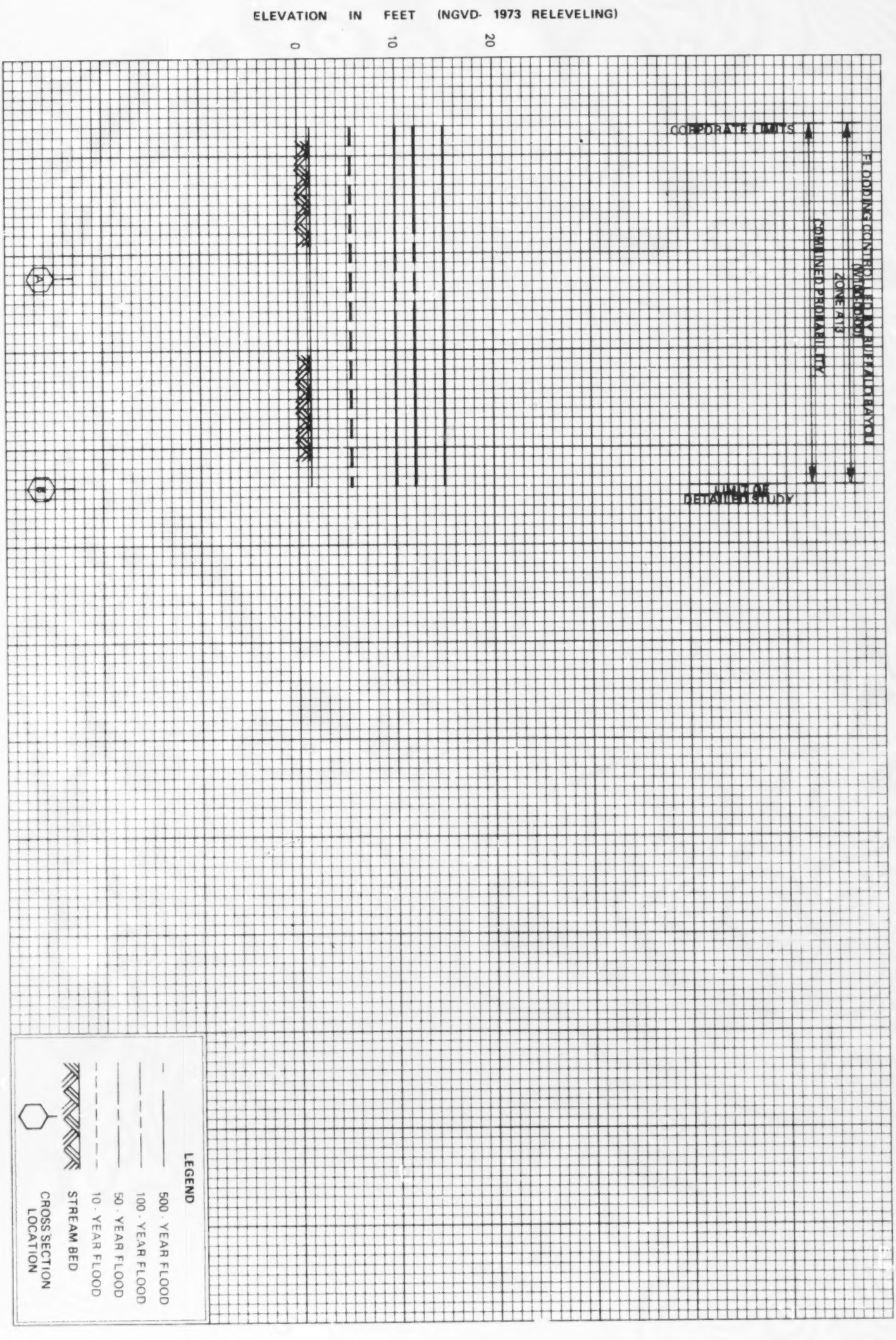


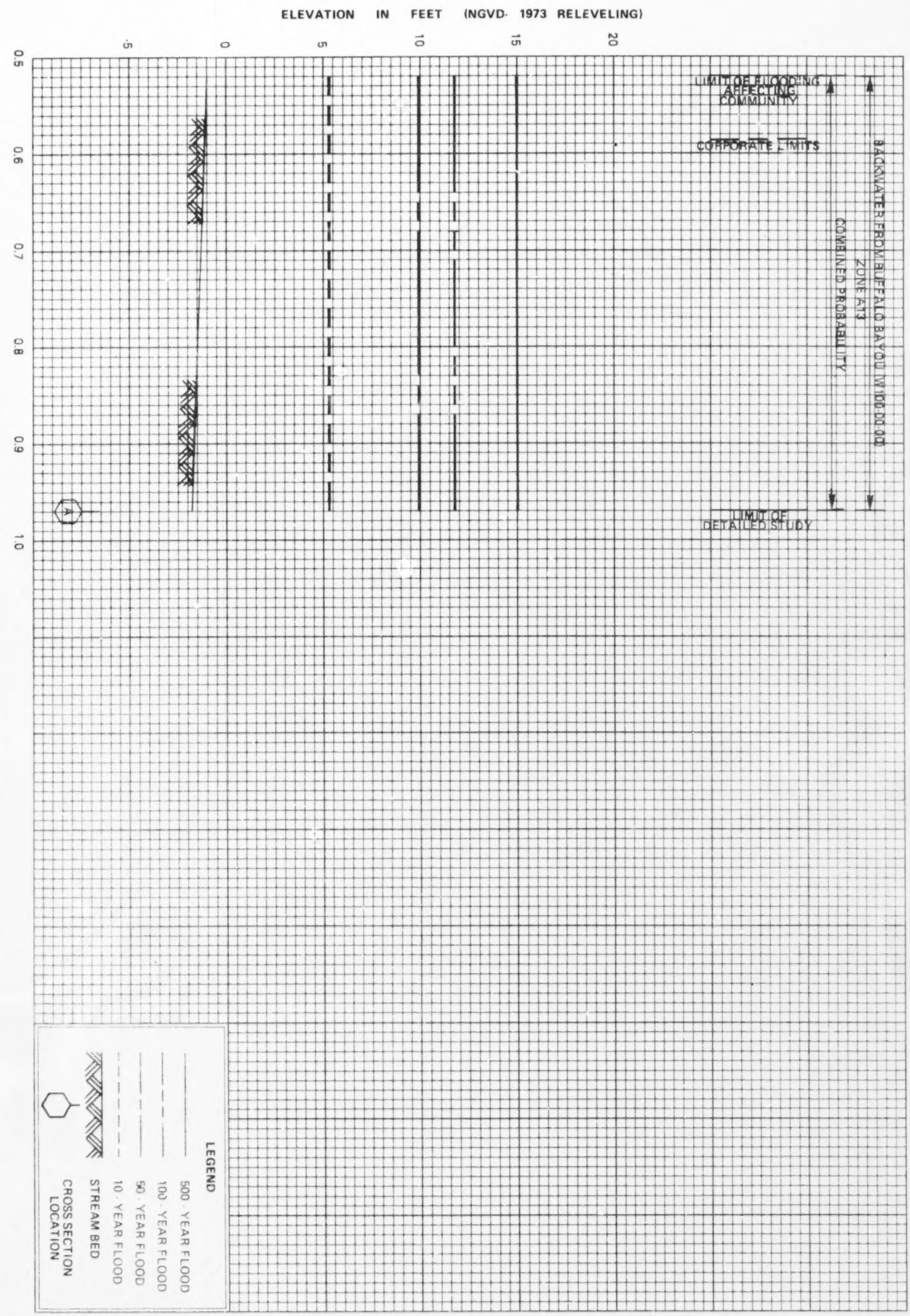
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

TRIBUTARY 6.77 TO BUFFALO BAYOU

15P



16P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

TRIBUTARY 8.17 TO BUFFALO BAYOU

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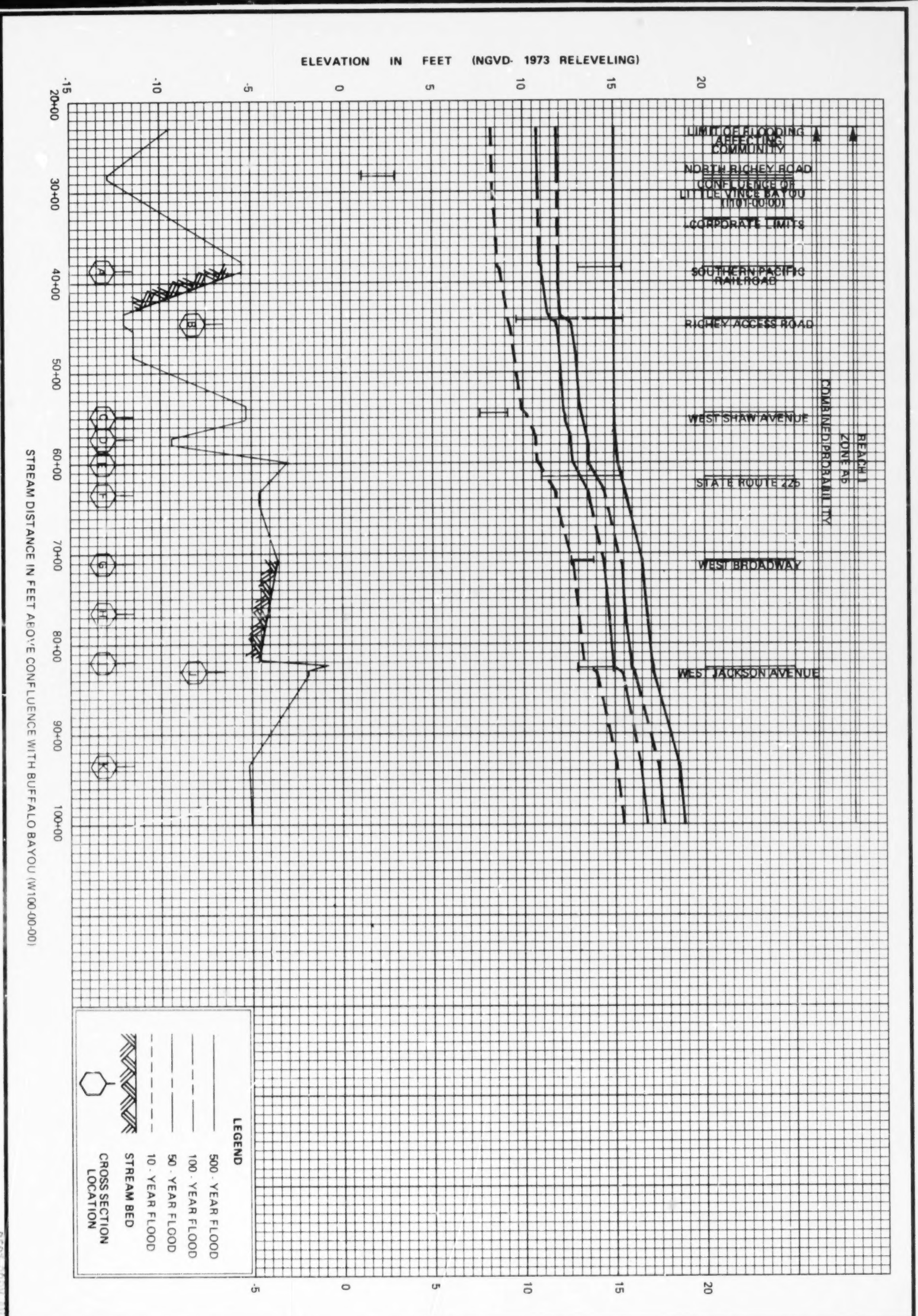

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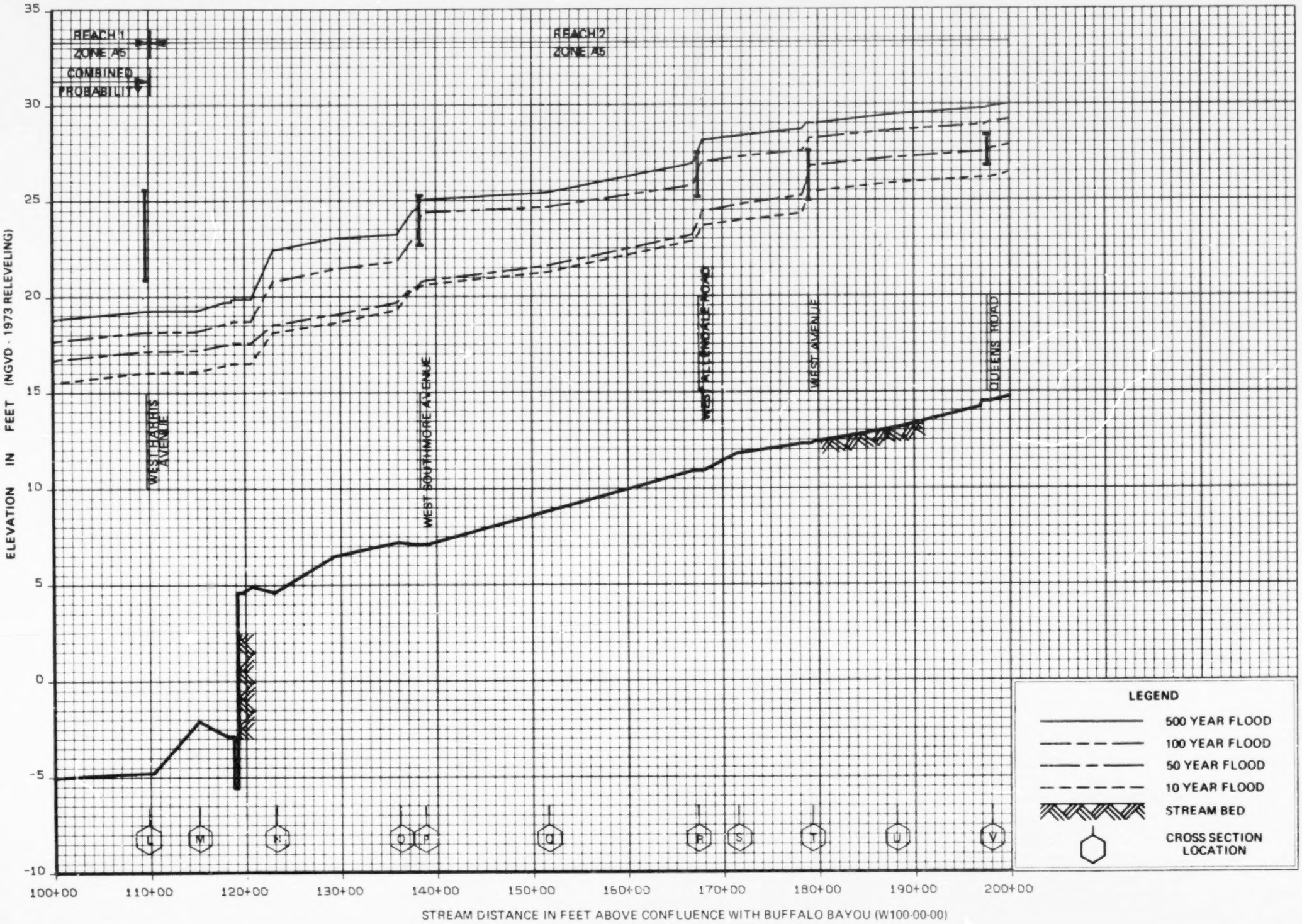

FLOOD PROFILES

VINCE BAYOU (I100-00-00)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

18P

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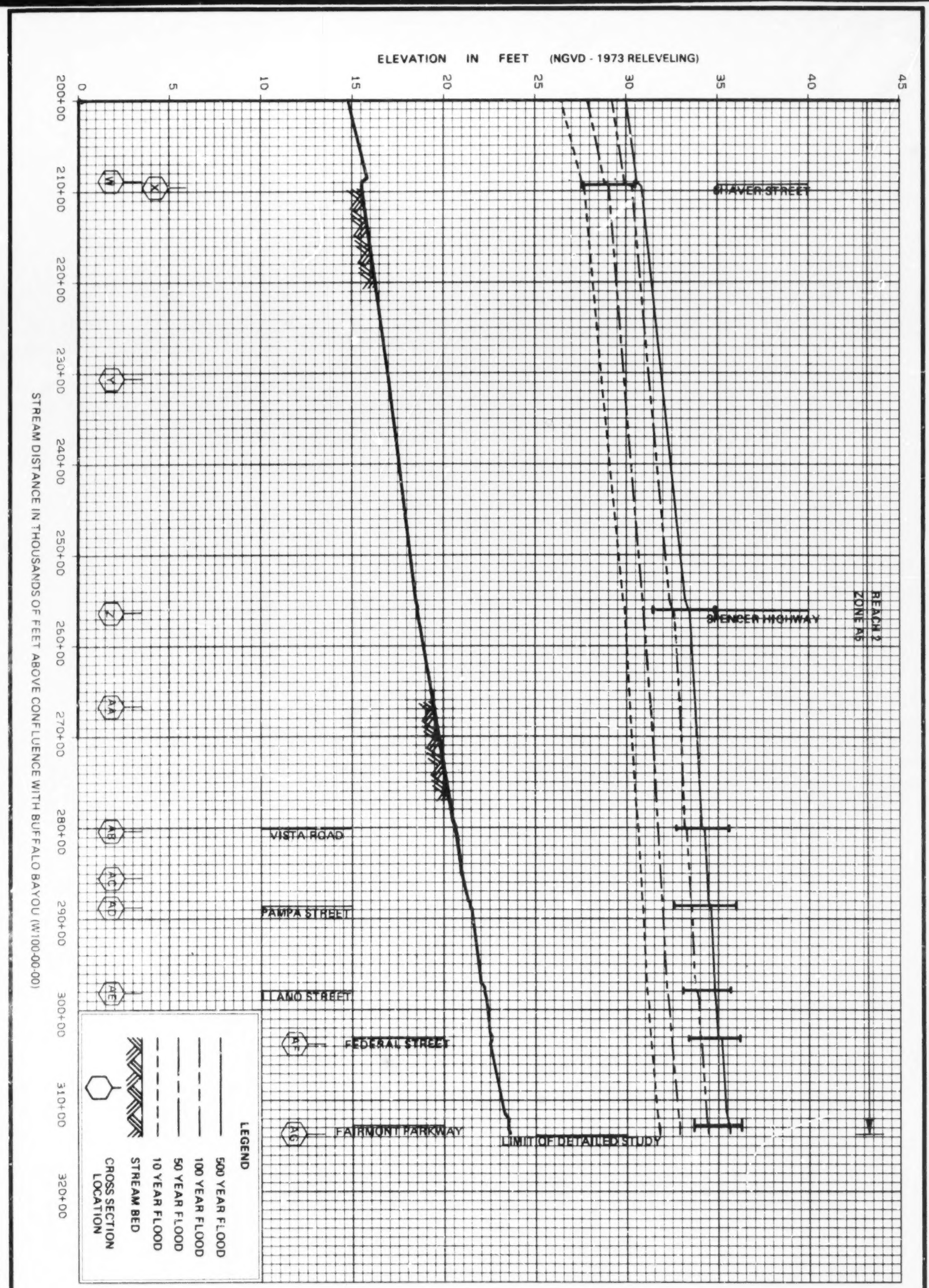


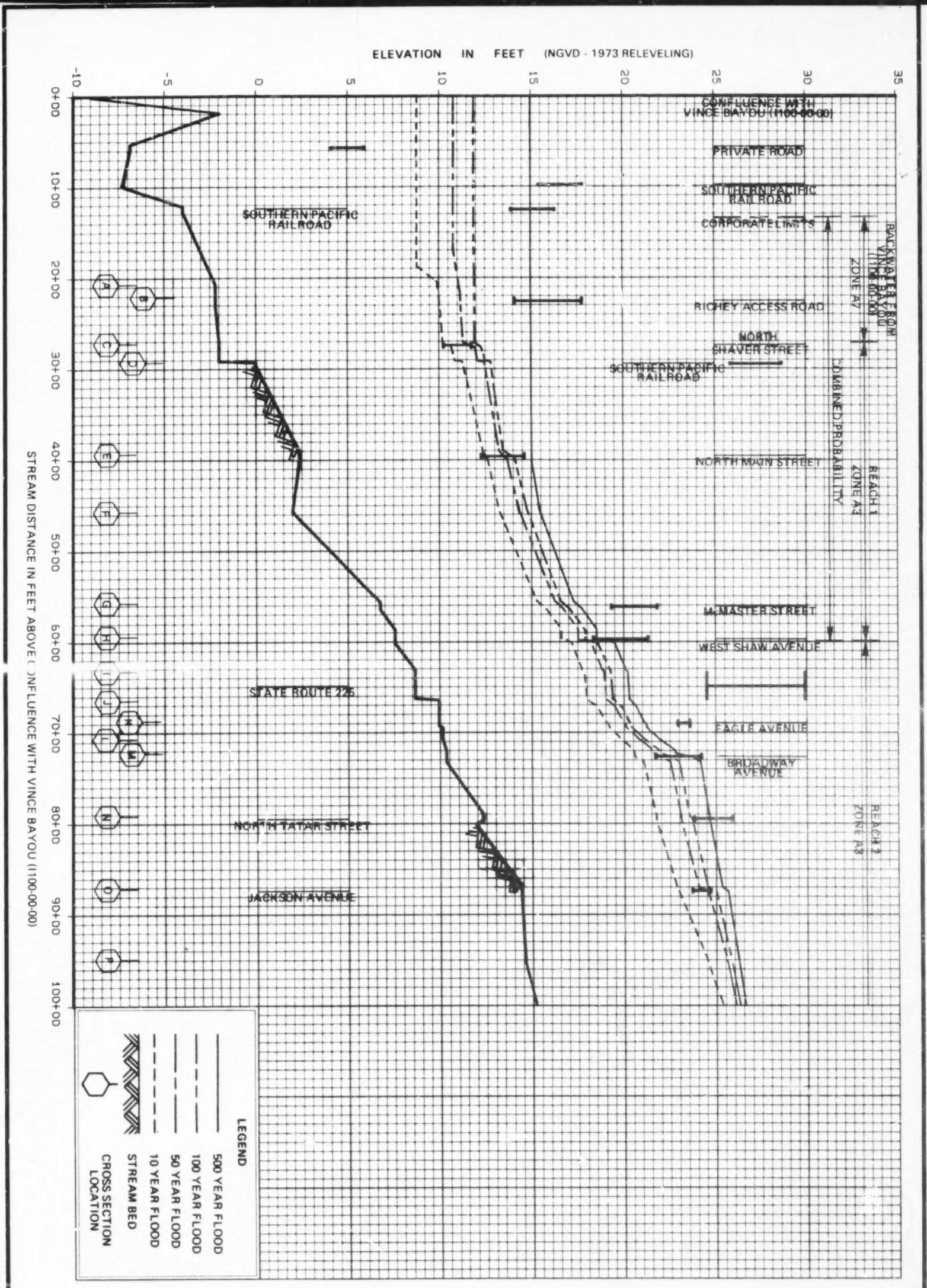
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

VINCE BAYOU (1100-00-00)

19P



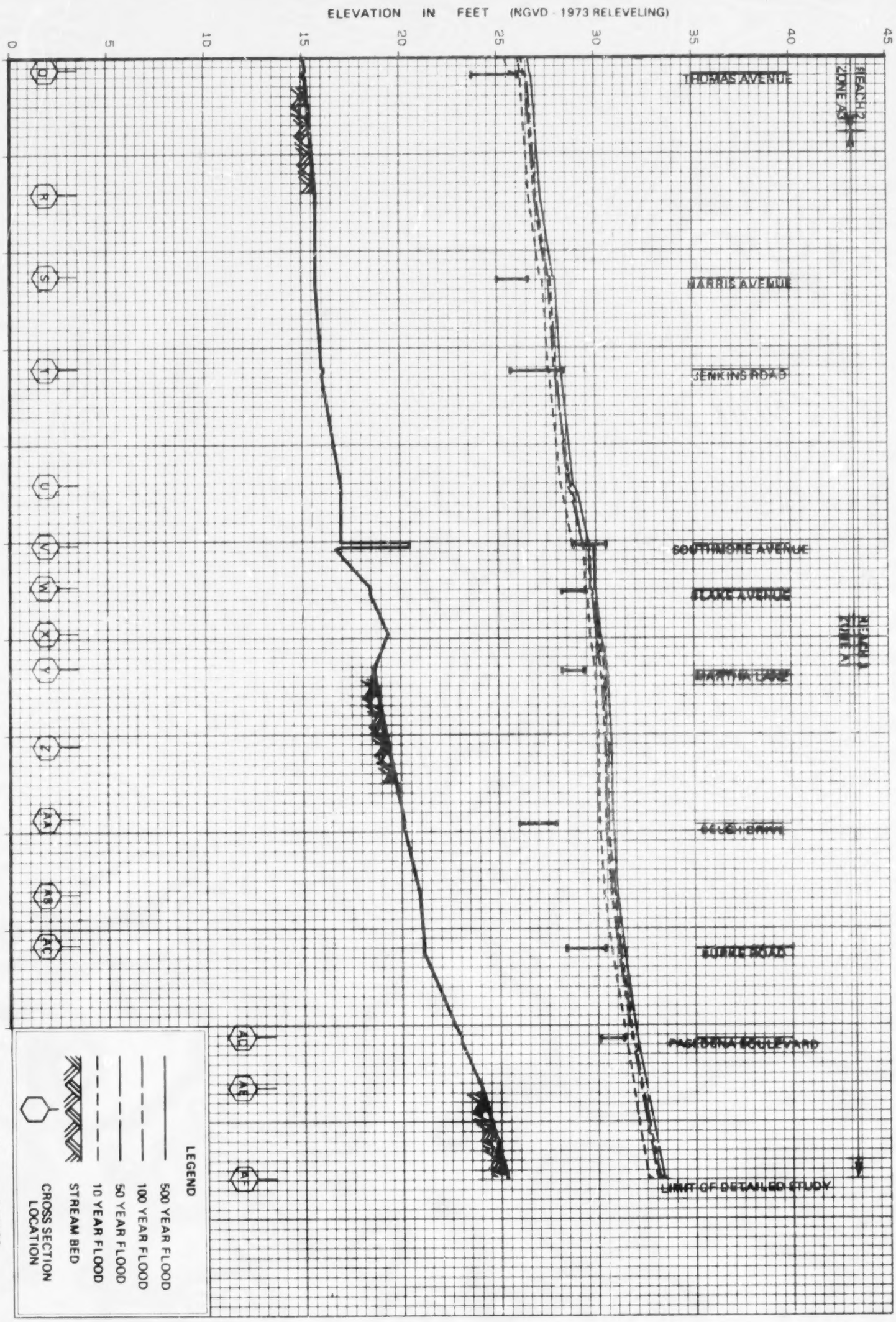
20P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

LITTLE VINCE BAYOU (1101-00-00)



21P

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PASADENA, TX
(HARRIS CO.)

FLOOD PROFILES

LITTLE VINCE BAYOU (1101-00-00)